OBSERVATIONS OF SOLID WASTE MANAGEMENT IN BOMBAY, 1992

OBSERVATIONS OF SOLID WASTE MANAGEMENT IN BOMBAY, 1992

Compiled by Manfred Scheu and Adrian Coad

The observations were made by study-fellows on a course conducted by
The Water, Engineering and Development Centre (WEDC),
Loughborough University of Technology, UK and
The All India Institute of Local Self Government, Bombay, India.

The course was sponsored by the Ministry of Urban Development, Government of India
and The Overseas Development Administration (ODA) of the British Government.

The assistance and co-operation of the
Municipal Corporation of Greater Bombay is gratefully acknowledged.

Published by WEDC
Loughborough University of Technology
Leicestershire LE11 3TU UK
1994

ISBN: 0 906055 40 7

The Water, Engineering and Development Centre (WEDC) is concerned with education, training, research and consultancy for the planning, provision and management of physical infrastructure for development in low and middle-income countries.

Printed by The All India Institute of Local Self Government, Bombay, India

SOLID WASTE MANAGEMENT IN K-WEST WARD, BOMBAY

INTRODUCTION

This report was prepared as part of a training course jointly organised by the Ministry of Urban Development of the Government of India and the Overseas Development Administration of the British Government. It is a compilation of the information collected and analysis based on this information.

The course comprised a five week component in Britain, at WEDC, Loughborough University of Technology, during which the study fellows participated in seminars led by a number of British experts, and visited some sites concerned with solid waste collection and disposal. It was followed by a three week component that was held at the All India Institute of Local Self Government in Bombay, and it was during this part of the course that the information presented here was collected.

The reader is asked to remember that this report does not carry the weight of a consultant's report. It was compiled in a period of about two weeks, and though there was an impressive aggregate of experience among the study fellows, they did not have time to examine all the issues thoroughly. Nevertheless, this report should provide many useful insights and suggestions which are worthy of more detailed examination.

The study fellows were divided into four groups, each group considering particular aspects of solid waste management. The main focus of the exercise was K West Ward in Greater Bombay, though some of the subjects necessarily were on the city level rather than on the ward level. The four subject areas,(and the four parts of this report) and the study fellows in each group (and their posts at the time of the programme) were as follows:

Part A Administrative and financial aspects of solid waste management

Mr D S Manhas	Commissioner	Shimla Municipal Corporation
Dr B P Patnaik	Medical Officer of Health	New Delhi Municipal Committee
Mr V K Rao	Assistant Engineer	Municipal Corporation of Greater Bombay

Part B Primary collection and storage in K-West Ward

Mr S A Gaikwad	Scientist	NEERI, Nagpur
Mr D N Gupta	Addl Chief Engineer	New Delhi Municipal Committee

Part C Collection and transport in K-West Ward

Mr Z A Sacha	Deputy Director of SWM	Ahmedabad Municipal Corporation
Mr H S Verypam	Executive Engineer	PHED, Imphal
Mr K Watal	Asst Executive Engineer	Jammu Municipality

Part D Resource recovery and disposal in Bombay

Mr M T Bondre	Executive Engineer	Municipal Corporation of Greater Bombay
Mr R C Dixit	Scientist - C	NEERI, Delhi
Mr D K Ghosh	Executive Engineer	Assam Urban WS&S Board

The course tutors were Mr Manfred Scheu and Dr Adrian Coad.

The report is presented in four Parts, as indicated above. Appendices relating to each part are located at the end of the particular part, rather than at the end of the whole report. The start of each part is indicated by a green sheet, and the start of the appendices for each part is marked by a blue sheet.

The preparation of this report, and the second phase of the course, would not have been possible without a high level of support from a number of sources. The authors of this report would particularly like to thank Prof Mrs Sneha Palnitkar and her colleagues from the All India Institute of Local Self Government (AIILSG), Mr C D Kotnis (Chief Engineer) and his dedicated team at the Municipal Corporation of Greater Bombay, including Mr A A Vaid, Ward Officer, and Shri Anant Jadar, Municipal Councillor. The support of the Ministry of Urban Development and the Overseas Development Administration are also gratefully acknowledged.

LIST OF ABBREVIATIONS

AHS	Assistant Head Supervisor
AIILSG	All India Institute of Local Self Government
BMC	Bombay Municipal Corporation (now MCGB)
BP Act	Bombay Police Act
CE	Chief Engineer
CTIRC	Central Training Institute and Research Centre
DC	Drain Cleaner
DCE	Deputy Chief Engineer
DHS	Deputy Head Supervisor
DMC	Deputy Municipal Commissioner
EP Act	Environment Protection Act
HO	Health Officer
HRD	Human Resources Development
HS	Head Supervisor
JO	Junior Overseer
Km	Kilometre
MC	Municipal Commissioner
MCGB	Municipal Corporation of Greater Bombay
MLA	Member of Legislation Assembly
MP	Member of Parliament
ND	Nuisance Detector
NGO	Non Government Organisation
PCB	Pollution Control Board
PRO	Public Relations Office
R&D	Research and Development
Rs	Indian Rupees (Exchange rate in 1992 approx. Rs 44 to £ 1 sterling)
SI	Sanitary Inspector
SSLC	Senior School Leaving Certificate (12 years of school level study)
SWM	Solid Waste Management
SWMD	Solid Waste Management Department, K-West Ward
WO	Ward Officer

GLOSSARY

Chowki A place (post) for control and monitoring of refuse collection crews (see Muster Chowki and Motor Loader Chowki).

Community bin Communal storage facility for refuse.

Compactor trolley Standard refuse container (capacity 1.0 cum) used in conjunction with compactor trucks. (See figure B-2.11)

Crore Ten million.

Dumper placer More commonly called skip truck, it can lift, carry and empty one container.

Dumping ground Landfill site

Halalkhore Labourer who removes human excreta.

Hawker Person who buys recyclable materials directly from households, door-to-door

K-West Ward One of 23 wards in Bombay (study area).

Lac, Lakh One hundred thousand (ten lakhs are one million).

Log slip A form for holding data about the load, time of loading and unloading of a refuse vehicle.

Motor loader Person who loads the solid waste manually onto a refuse collection vehicle.

Motor loader chowki Place (post) where crews of refuse collection vehicles meet.

Mukadam Foreman of sweepers and drain cleaners (promoted from among sweepers and DC's).

Muster chowki Office of Junior Supervisor, taking attendance, giving instructions or holding meetings with mukadams and labour.

Nuisance Detector A sweeper level person to detect and apprehend any nuisance creator in public places under Bombay Police Act.

Pipe bin A short section of a large diameter steel pipe, used for refuse storage.

Picker, or **Rag picker**, A person who collects recyclable material like paper, glass and rags from refuse, more commonly called scavenger.

Refuse shed Enclosed masonry structure, usually with a roof, used for storage of refuse.

Stable Place where cows or buffaloes are kept.

Sweeper Labourer sweeping roads (in India sometimes called a scavenger).

Tata Compound Location of the Office of the SWM Department in K-West Ward.

Trolley, trolley bin (See "Compactor trolley" above)

Ward Officer An officer who discharges all the functions of Municipal Commissioner in a ward as delegated by the Municipal Commissioner.

PART A

ADMINISTRATIVE AND FINANCIAL ASPECTS OF SOLID WASTE MANAGEMENT IN K WEST WARD, BOMBAY

LIST OF CONTENTS

A-1. INTRODUCTION

This part reviews administrative and financial aspects at the ward level (Ward K West - Andheri) and at city level. It also discusses the management of clinical and industrial solid wastes.
The information was obtained by means of interviews with the Ward Officer (WO), officials of K-West Ward and officers of the SWM Department of the MCGB. Information was also collected from the public, from councillors, official records, public- and private hospitals and from the office of the Pollution Control Board (PCB).

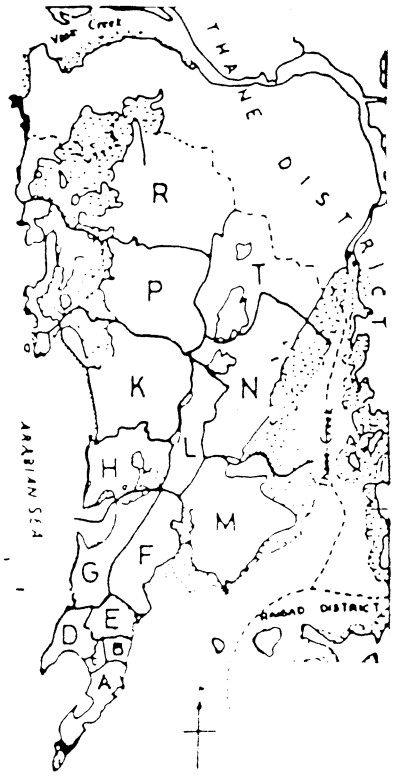
A-2. DESCRIPTION OF THE STUDY AREA

Some general features of the study area are outlined briefly in Section A-2.1 before present solid waste management procedures in K-West Ward are described in A-2.2.

A-2.1 General features of the K-West Ward

K-West is one of 23 wards in the city of Bombay. The total area of this ward is about 23.29 square kilometres with a population of about 580,000 (1991 census, 5.8 lakhs). Middle and high income housing areas consist primarily of high rise buildings; in addition there are 68 declared slums in K-West Ward (7 on municipal land, 15 on Government and 46 on private property). The location of K-West Ward is shown in Figure A-2.1.

Figure A-2.1: Greater Bombay Wards



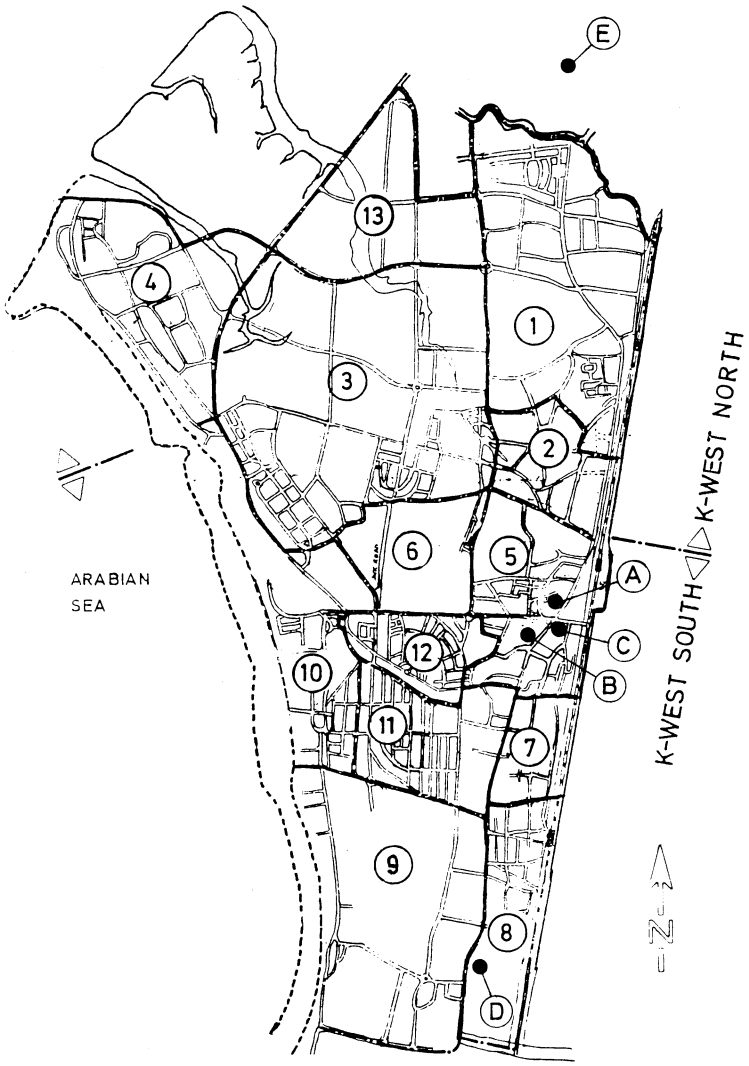
WARD	AREAS
A	Colaba - Fort
B	Mandvi - Chakala Umarkhadi - Dongri
C	Kumbharwada - Buleshwar Dhobitalao - Answadi
D	Khetwadi - Girgaon Walkeshwar - Mahalaxmi
E	Tardeo - Mazagon - Nagpada Kamathipura - Byculla
F	Parle - Sewri - Naigaum Matunga - Sion
G	Dadar - Mahim - Prabhadevi Worli - Chinchpokli
H	Bandra - Khar - Pali Santa Cruz
K	Vile Parle - Juhu - Andheri Jogeshwari - Versowa
L	Kurla
M	Chembur - Mahul - Mankhurd Deonar - Trombay
N	Ghatkoper - Vikhroli - Bhandup
P	Goregon - Aerey - Malad - Manori
R	Kandivli - Borivali - Akurli - Eksar - Dahisar
T	Mulund

The ward is represented by eight Councillors, two Members of Legislative Assembly (MLA) and one Member of Parliament (MP).

A-2.2 Solid waste management system in K-West Ward

For the purposes of solid waste management [SWM] the ward is divided in two administrative zones (northern and southern zones). These zones are further divided in 13 SWM districts as shown in Figure A-2.2.

Figure A-2.2: SWM facilities and SWM districts in K-West Ward



KEY

1 to 13 SWM districts

A SWM Department
B Ward Office
C Muster Chowki
D Santa Cruz workshop
E Vehicle checkpoint

Street sweeping and drain cleaning activities are organised by Junior Overseers (JO's), who are assigned to the SWM districts (one JO per district). There are eight Muster Chowkies (Junior Overseer Offices) located in K-West Ward. Municipal sweepers, drain cleaners (DC's) and mukadams (foremen) meet in these chowkies and day-to-day duties are assigned to them by JO's.

Street sweeping and drain cleaning activities are carried out seven days per week (single shift operation).

Community bins and containers are used for storage of domestic and commercial refuse as well as for storage of street sweepings. In addition about 925 premises, mainly high rise flats and hotels, are served by house to house collection.

Figure A-2.2 further shows the location of the Ward Office, the Solid Waste Management Department (SWMD) and of Santacruz Workshop.

Refuse collection and transport is carried out by vehicles of the SWMD (16 vehicles) as well as by vehicles and drivers of private contractors (25 vehicles including drivers). Personnel of the SWMD (motor loaders and mukadams) are assigned to all vehicles at the Motor Loader Chowki (see Figure A-2.2). Vehicle loads are recorded at a Check Point (see Figure A-2.2) before the trucks leave to the disposal site.

Collection and transport is carried out in two shifts, seven days per week (with reduced crews on Sundays).

According to information obtained from the Ward Officer (WO) the total amount of refuse collected in K-West is about 170 tons per day.

In addition, removal of debris (mainly construction waste) is entirely carried out by a private contractor (using 8 vehicles and providing labourers).

Collection, transport and disposal aspects are analysed by Groups B, C and D respectively. Organisational aspects are discussed in section A-3 below.

A-3 ORGANISATION AND MANPOWER

This section is subdivided in five subsections as follows:
The existing organisation structure is discussed in A-3.1 before procedures for data collection and monitoring are set out in A-3.2. Section A-3.3 deals with personnel management and workers' health, and A-3.4 with qualifications and training aspects. Finally, public relation functions are analysed in Section A-3.5.

A-3.1 ORGANISATION STRUCTURE

Based on information obtained from the Chief Engineer/SWM (CE/SWM) the organisational chart of the Solid Waste Management Department (SWMD) of Municipal Corporation of Greater Bombay (MCGB) is shown in Appendix AA-I.1.

The CE/SWM at central level is assisted by a Research and Development wing (R&D wing) consisting of one Executive Engineer, three Assistant Engineers and Sub-Engineers. Finalisation of annual contracts and purchase of sanitary equipment is the responsibility of the R&D wing.

According to information obtained in the SWMD the number of supervisory and administrative staff provided at each level is considered sufficient.

Appendix AA-I.2 shows the organisational chart of the SWMD in K-West Ward.

It is shown in the figure that there is a well structured organisational set-up in SWM with sweepers at the lowest level and AHS heading the department.

The supervising cadre at K-West Ward level consists of 17 Junior Overseas (JO's), two Supervisors and one Assistant Head Supervisor (AHS). Out of the 17 JO's 13 are assigned

to SWM districts, 2 are responsible for transport arrangements and 2 are based at the vehicle checkpoint (one per shift).

The AHS is the in charge of conservancy staff in the ward and is responsible for all activities of the SWMD in the ward, under the direction and control of the WO. For technical guidance and control the AHS reports to the DHS (at central level), who in turn is guided by HS, DCE and CE/SWM.

The total number of labourers who are permanently employed in K-West Ward for SWM is 876. This includes 77 mukadams, 498 sweepers, 19 drain cleaners, 135 halalkhores and 147 motor loaders. In addition there are about 340 labourers who are employed on a daily wage basis.

Relating the number of labourers to the inhabitants of K-West Ward, the staffing ratio is about 2.1 labourers per 1,000 inhabitants (876+340 labourers x 1,000 / 580,000 inhabitants).

A-3.2 DATA COLLECTION AND MONITORING

This section will provide some information regarding solid waste transport records. The record system employed in Muster Chowkies (sweepers, DC's and halalkhore) is described in Part B.

(i) Monitoring of refuse collection vehicles

The JO at the Motor Loader Chowki keeps an entry register of MCGB and contractors vehicles employed in K-West for refuse collection. Vehicle loads are recorded at a check point before they leave to the dumping ground. At the dumping ground the log slips are checked and stamped and an entry is made in a register. At the ward level and at the Central Office this data is collected and maintained. This provides a counter check for monitoring the shortfalls of vehicles between the requirements of the field staff and the supply by the contractor and municipal transport staff. The information is compiled at the Central Office by the CE/SWM and submitted by the DMC to the Commissioner. In case of a shortfall of vehicles in K-West Ward during the day vehicles are requisitioned at night and the backlog is cleared. Standing instructions exist to cover this eventuality.

SUGGESTION: The record keeping system described appears to be functioning well and be proper and adequate. However, it has been observed that, even in the Central Office all records and files are kept manually without using modern data processing equipment Therefore the capabilities of processing the data are limited. Considering the very large number of data collected it may be advisable to introduce computer technology and software for data processing. The use of computerised data recording and processing systems should probably start at the central level before being extended to the ward level.

(ii) Exchange of information and data

At present there is no institutional arrangement for regular exchange of information between MCGB and other bodies in the country. AIILSG through its publications disseminates reports on the adoption of new technology but not on the longer-term results and operational aspects.

SUGGESTION: It may be advantageous to introduce a SWM data exchange system between municipal corporations of major cities in India. The MCGB could, for instance distribute an annual review of main activities, innovations and experiences in the SWM sector and encourage other municipal corporations to provide similar information.

A-3.3 PERSONNEL MANAGEMENT AND WORKERS' HEALTH

Aspects of personnel management are divided into supervision and control [paragraph (i)], recruitment and promotion [paragraph (ii)], motivation [paragraph (iii)] and finally workers health in paragraph (iv).

(i) Supervision and control

The supervisory cadre at the ward level consists of JO to AHS as shown in Appendix AA-I.1. Inspection rounds of JO's and supervisors are considered adequate but they seem to be demoralised on account of the Union's militancy and politicisation of strikes. There are no incentives provided for good performance from JO's to HS level and there is no input of technical know how at this level. This was admitted and confirmed by a JO off the record.

The AHS is controlled twice, i.e. he reports to WO for operation control and DHS at the central level for technical matters. According to discussions held with the DCE and AHS the system is working smoothly without any contradiction.

Due to different technical backgrounds the interaction between the Research and Development (R&D) and the Operational wing is non-existent. The R&D wing does not seem to have surveyed the ward to assess the generation of refuse in the areas in order to provide an adequate number of community bins and containers to the localities. As a result it has been reported that many of the bins are overflowing. This was confirmed by an inspection when refuse was found outside all of the 35 community bins inspected.

Regarding supervision of workers it has been reported that only a small percentage of sweepers, mukadams and motor loaders wear the uniforms provided by the SWMD. Reasons may include that they prefer to remain inconspicuous in order to be able to work in private premises during official working hours. It has been mentioned that enforcement of wearing uniforms is difficult because there is only one uniform provided per person. Therefore washing and repair is always an excuse for not wearing the uniform.

SUGGESTIONS:

- There was some indication that municipal engineers are not happy to be posted to solid waste management, and so they do not show much interest in their work and try to get transferred to a different responsibility as soon as possible. Consideration should be given to finding ways of making solid waste management more attractive to engineers. This might be done by encouraging engineers to make a career in solid waste management by making the posts non-transferable. Other measures would also be needed to improve the status and working conditions of solid waste management engineers. The same argument applies to the post of Public Health Engineer in the wards.

- It is further considered necessary to re-examine the duties and functions of DHS and HS and to define their duties properly in respect of supervisory control (e.g. JO's through AHS should give information in respect of overflowing bins). This may include the introduction of formatted records to cross check the actual supervision done which seems to be quite relaxed at the moment. Appendix AA-II suggests the layout of a proforma which could be employed for this purpose.

- To ease supervision and to reduce the time spent during official working hours by sweepers working unofficially on private premises for individual gain, the wearing of uniforms should be strictly enforced. Therefore sweepers, DC's and halalkhores should each be provided with two sets of uniforms and identification badges and instructed to

wear them during official working hours. This could further include the introduction of a master-roll card system for labour (i.e. cards are filled in by the JO's in the morning and held by the workers).

- For indirect control at the ward level a 'Safai Watch Committee', headed by the Local Councillors and consisting of 5 or 7 prominent citizens, may be formed to assist the AHS and to achieve stricter supervision. The Public Health Engineer may be involved in this activity.

- Another suggestion to improve supervision may be the introduction of an Inter-Ward Competition for the entire supervisory staff (from JO to AHS). A cash award may be given along with a citation as an incentive (For example, a cash award of Rs 500 for JO's, Rs 700 for Supervisors and Rs 1000 for the AHS would amount to an additional annual expenditure of about Rs 70,000, but it is likely that the savings from higher productivity would be many times this figure.)

(ii) Recruitment and promotion

Recruitment and promotion policies are well defined for the entire staff. A deserving and ambitious sweeper can rise up to the level of HS. Based on seniority and subject to suitability, sweepers, halalkhores and DC's may be promoted to mukadam. Labourers and mukadams doing especially good work are rewarded in kind every year on the recommendations of AHS.

The provisions of punishment for delinquent staff exist under the BMC Act. Measures for the punishment of sweepers, halalkhores, DC's and mukadams include rotation in the ward. All other posts are transferable throughout the Greater Bombay area after a normal tenure of 3 years. The engineering staff of SWM is transferable within the MCGB but the staff from JO to AHS are non-transferable outside the SWMD. Therefore it can be concluded that there is an adequate provision for disciplinary action for delinquencies as well as for rewards for good work.

According to information obtained, about 2/3 of the vacancies at JO level are filled by direct recruitment and 1/3 by promotion from eligible staff within the department. It has been reported that the majority of sweepers and mukadams are employed for many years with the MCGB and that there is no shortage of labour. In fact, most of the workers, who are actually employed on a daily wage basis, would prefer to become permanent employees of the SWMD. Reasons include that the pay scales and salary of SWM staff (see Appendix AA-IV.1) are quite comparable and even rather better than those of equivalent employees in the private sector and other parts of the public sector.

SUGGESTIONS:

- Due to the high job satisfaction of labour there seems to be little or no need to provide additional incentives. This situation may allow some freedom to increase the work load of these personnel (see (iii) below). However, for providing social security, the three categories - sweepers, DC's and halalkhores - should be offered an insurance under a group insurance scheme, covering disablement and death (e.g. for cover of up to Rs 50,000/-, fees of about Rs 50/- per month may be deducted from each worker's salary).

- There may be benefit in using names with less of a social stigma than *halalkhores, sweepers* and *drain cleaner*. Job titles such as 'Safai Kamgar', 'Safai Karamchara', or any other respectable name might improve the public perception of the work. Improving the prospects and working conditions of workers by training and improved medical health care are discussed in (iii) and (iv) below.

(iii) Motivation

The general level of efficiency and workmanship is fairly low amongst mukadams, sweepers and loaders. According to information provided by one of the supervisors, only about 70% of the staff are available for actual work on any particular day. Records of one section in K-West North (on 1-12-92) indicate that out of 91 sweepers only 64 had presented themselves for work - 11 were absent, 5 on casual leave and 11 were taking their normal weekly day off). It has been further alleged that for seven days after receiving their wages 30% of the staff do not report for duty for almost a week because they are drunk.

Finally, it has been reported that sweepers and motor loaders do not work more than 3 1/2 hours in a shift of 7 hours (see Parts B and C). The remaining time is used to work on private premises for individual gain. The Union's militancy and loose supervision by mukadams and JO's contribute towards indiscipline and absenteeism.

Measures to increase the efficiency of mukadams, sweepers and loaders seem to be very difficult to implement because of the Union's militancy and politicisation of strikes. However, considering that about 73% of the total expenditure of SWM is spent on wages and salaries it is considered crucial to achieve an adequate performance of labour.

SUGGESTION: Possible routes for achieving increases in productivity may include a ban on fresh recruitment for vacancies arising out of promotions, retirements etc. for a period of at least 5 years. Other possible measures for increasing the efficiency of labour are discussed in Parts B and C. This may further include the involvement of the private sector in solid waste collection services as outlined in section A-4 below.

(iv) Workers' health

Sweepers, halalkhores and motor loaders are not provided with any kind of protective equipment. This results in health hazards to SWM staff. Appendix AA-VI shows that the total cost of equipping the workforce with protective equipment would be about Rs 10 lakhs. In addition there are no medical check ups for labour provided by the MCGB.

SUGGESTIONS

- All motor loaders, DC's and halalkhore as well as staff at the landfill site should be provided with protective gum boots, hand gloves and uniforms. The type of boots and gloves should be decided in consultation with the work-force, and they should be required to wear them. It has been further suggested to provide protective glasses to the motor loaders working with conventional trucks. To make sweepers more visible on vehicular roads it may be considered to provide them with shirts that have reflective bands.

- A thorough medical check-up should be provided at no charge to all manual personnel employed by the SWMD. This would allow the monitoring of health hazards faced by the staff and improvement of the working conditions.

A-3.4 QUALIFICATION AND TRAINING

Education and training qualifications of SWM personnel and training of manpower are discussed in (i) and (ii) respectively.

(i) Qualifications

The basic qualification for JO is SSLC pass and one year Sanitary Inspector (SI) course at AIILSG. From JO to AHS level there are compulsory training courses run by CTIRC.

The minimum educational qualification for sweepers, halalkhores and DC's is first level standard education.

It has been mentioned that the appointment of engineering staff to the SWMD is treated as a kind of unwanted posting outside the mainstream of engineering and that engineers of the SWMD would therefore work without much interest in their jobs.

SUGGESTIONS

- Since the qualifications for JO onwards are SSLC it is felt that the exposure of such staff in the academic and technological field is limited. To improve the qualifications from supervisor onwards, completion of the Sanitary Inspector Course 1 may be considered as a requirement. In addition managerial and technical training inputs should be provided to this level.

- It is considered that, at ward level, being in charge of SWM should be a technical and senior post (e.g. a public health engineer 2). This would probably allow for better communication with other levels of the administration and would also provide better knowledge regarding the use of SWM data. The drawback is that engineers do not like postings in SWM. Therefore the SWM posting of engineers should be non transferable to other departments and the posts of DCE and CE could become a promotion post for departmental candidates.

(ii) Training

Sweepers, mukadams and motor loaders are the cutting edge functionaries in SWM department. It is unfortunate that no formal or informal training is provided to these personnel. In addition no efforts are made to impress upon them the importance of the work they carry out.

SUGGESTION: To ensure that the major workforce of the MCGB becomes more qualified some training should be provided at the lower levels. This may involve the trainers and facilities of the CTIRC, where training courses for more senior level personnel of the MCGB are held. It has been suggested that a three-day training course at CTIRC should be prepared for mukadams, sweepers, DC's and halalkhores (see Appendix AA-III). However, considering the large number of potential trainees (about 6,000) it is considered doubtful whether the capacity of the training institute is sufficient to conduct courses with a duration of several days. It is therefore suggested to further evaluate training needs and capabilities and to conduct some pilot sessions to establish the most suitable procedure. In any case audio visual media may be used and the workforce should be made aware of the importance of the work they are doing for society. The programme may aim at training the entire staff over a period of about 3 years, starting from junior-most employee. Refresher courses should be run after 5 years. The cost for introducing a three days training course may be about Rs 12 lakhs per year.

A-3.5 PUBLIC RELATIONS FUNCTIONS

Public relation functions of the SWMD are discussed in this section and include procedures for handling complaints [paragraph (i)] and publicity and awareness campaigns [paragraph (ii)].

(i) Handling complaints

At ward level replies to complaints are provided in writing to the complainant after the complaints have been attended to, and there is a well-defined procedure for receiving and handling complaints.

It has been observed that the records of the Complaints Officer in the Ward Office are quite up-to-date. However, record maintenance at the Central Office of MCGB is considered inadequate for monitoring purposes. At present the CE Office does not have any records of complaints.

SUGGESTION: To improve the co-operation between ward and central level it is suggested that the Complaint Officer sends a copy of every complaint, after action has been taken on it, to the CE Office (SWM). This would allow the Research and Development cell to analyse recurring complaints and take corrective measures. A modified procedure for better monitoring is suggested in Appendix AA-V. This procedure would allow the Central Office to research the data and to react more adequately.

(ii) Publicity and awareness campaigns

According to information obtained from the Public Relations Office (PRO) it was revealed that no special campaigns for educating children and the general public had ever been undertaken in respect of solid waste. However, special campaigns on conservation of water and planting more trees have been conducted by this office.

With regard to solid waste management and education of public in respect of the BMC Act, the Environmental Protection Act and other related laws, the contribution of PRO is negligible.

It was further observed that, during the last year, not even on a single occasion had any mass communication media been used to educate the public.

The group has also visited one municipal secondary school at the Tata Compound and met the Education Supervisor. She explained that there are chapters on personal and social hygiene in the curriculum of classes V to VII and VIII to X respectively.
However, it was mentioned that there had been no interaction between the school, the Health Department and the SWMD.

Although the theoretical inputs in the school curriculum may be sufficient to impart an idea of solid waste hazards to the students they may not make a sufficient impact in absence of any audio-visual aids. School children and teachers have never been associated in any kind of cleanliness campaign in and around the area. As a result the students are not practising what they learn during the lessons and practical situations cannot be visualised by the students.

This information suggests that the lack of publicity and public awareness campaigns may to be one of the most significant shortcomings in respect of solid waste management in Bombay. Some suggestions on how to improve the situation are outlined below.

SUGGESTIONS

- It is recommended that the Public Relations Office should be exhorted to take up community projects in all the wards regarding the involvement of the public in keeping Bombay clean.

- The use of mass media such as All India Radio, Bombay, Bombay Doordarshan and newspapers is suggested for disseminating information to the public, and an advertisement campaign through radio and newspapers may be considered.

- Cleanliness campaigns could be organised, in which MLA's, MP's, schools and colleges become involved practically. It is further suggested that personnel of the SWMD of K-West Ward visit various schools and colleges and interact with the staff and students to encourage them to keep their schools and surroundings clean.

- Audio visual films regarding cleanliness and proper refuse disposal could be developed and used for education campaigns in schools and communities. Hand bills and posters, giving slogans and directions, may be developed and distributed through newspapers. In addition hoardings could be designed and displayed at prominent places, community centres, schools and colleges. Activities may further include the organisation of marches by school children for a clean city, involving the general public.

- Another idea for conducting publicity campaigns would involve practical co-operation and interaction between schools and solid waste management personnel. School children and SWM staff could be practically involved in cleaning an area around their school. In addition, groups of children, led by a mukadam or Junior Overseer, could visit people in their homes and educate them regarding littering, proper use of community bins and the need of keeping the surroundings clean. As an incentive the MCGB may provide some refreshments to schoolchildren and others from voluntary organisations participating in the campaigns. It is expected that the expenditures involved in these activities would be minimal and can be met from the normal contingency allocation.

- Another suggestion to promote cleanliness would involve the Ward Officer as a pivotal officer for all departments, including education. This will probably allow for involvement of local councillors who may be amenable to suggestions made by Ward Officers. Cleanliness marches could be organised in different wards and placards and banners, depicting cleanliness slogans, may be carried by people to educate the public. It may further prove effective to sponsor popular personalities to canvass for cleanliness awareness.

Without co-operation from the public, keeping the streets clean is an immense task, but when the public take care of their environment the workload on the municipal labour force becomes manageable. The measures described here may help to make cleanliness the people's programme and therefore lead to a more healthy and clean environment and significant cost savings.

A-4 INVOLVEMENT OF THE PRIVATE SECTOR

The involvement of private contractors in refuse and debris removal is discussed in Section A-4.1. Some potential options for privatisation of refuse collection services, based on the experience gained from a recent project for beach cleaning by the private sector, are outlined in Section A-4.2.

A-4.1 REFUSE AND DEBRIS COLLECTION BY PRIVATE CONTRACTORS

Separate contracts for the hire of refuse- and debris collection vehicles are awarded in individual wards. In the case of refuse collection, motor loaders and mukadams of the SWMD are assigned to the contractor's vehicles, whereas the debris collection contract includes the provision of labour.
The terms of both contracts are detailed and safeguard the interest of MCGB and private contractors. The contracts are too long to be reproduced here, but copies are available from MCGB or WEDC.

Both contracts are generally allotted on the basis of open competitive tendering for the period of two years. According to information obtained in the SWMD the period of two years has been chosen to allow for economic viability and the fluctuation of market rates of various components. Contracts are approved by the Standing Committee.

(i) Refuse transport by private contractors
As already mentioned in section A-2.2, private contractors are commonly employed for solid waste transport. The ratio of municipal vehicles to contractors vehicles for refuse collection is about 1 : 1,5 in K-West Ward and 1 : 2,5 in the MCGB as a whole.

According to the CE (SWM) the cost for refuse collection by contractors' vehicles is about Rs 400 per shift whereas the cost of municipal vehicles is around Rs 765 per shift. (Further comparisons of costs are presented in Part C.)
Reasons for the considerably lower cost per shift of contractors' vehicles include that these vehicles are standard trucks, usually very aged and without tipping devices. Municipal trucks are mainly special purpose vehicles, such as compactor trucks and dumper placers, equipped with a mechanically operated container handling devices. Therefore contractors' vehicles involve manual loading and unloading whereas municipal trucks can be used in conjunction with refuse containers and bins. Loading of municipal vehicles is therefore more hygienic for the loading crew and far less labour intensive. In addition the municipal vehicles allow the transport of refuse in an enclosed vehicle body with provision for rapid unloading at the disposal site. However, all vehicles, municipal (mechanical loading of containers) and private (manual loading and unloading) are operated by a crew of six loaders and one mukadam.
It is recommended that unit costs (that is, the cost per ton or the cost per cubic metre of refuse transported) are a better measure of economic efficiency than the cost per shift because compactor trucks are able to carry considerably more refuse per shift than open trucks.
A more detailed analysis of vehicles is provided in Part C.

SUGGESTIONS
- One of the main reasons for private contractors not to provide special purpose vehicles is the shortness of the contract period - 2 years. To achieve a more competitive situation between municipal and private vehicles an increase in the contract period to say five years should be considered, with an extension of the contract for another five years

possible under certain conditions. This longer period might encourage the contractor to buy more suitable vehicles.

- In an effort to reduce costs for the operation of special purpose refuse collection vehicles it is suggested that the inclusion of the provision of labour and even the provision of containers and their maintenance into contracts with the private sector be considered.

- Comparing the work involved in manual loading and unloading of a standard truck with the work involved in handling containerised systems it is hardly justifiable to assign the same crew size to both types of vehicle. Hence, adjusting the crew size to the requirements of the different vehicles offers a very significant potential for a reduction in labour costs for solid waste collection and transport. However, due to the militancy of the Unions this is considered virtually impossible within the public sector. Therefore privatisation of refuse collection and transport, introduced on a pilot scale and probably gradually extended, may be the only option to reduce the costs involved in refuse collection and transport.

Following the strategy that adequate refuse storage facilities should be introduced in Bombay and that manual loading and unloading of refuse is not acceptable, the bidding procedure for contacts should give preference to contractors who provide closed vehicles with mechanical container handling and unloading arrangements.

(ii) Debris collection and transport by private contractors

Collection of debris (mainly construction waste) is carried out entirely by private contractors and arranged by the AHS within his area of jurisdiction.

A 'debris removal register' is kept in the SWMD and JO's fill in the requirements for debris removal in their districts. JO's at the motor loader chowki (one per shift) use this register to assign the duties to debris collection crews of the private contractor. In addition one mukadam of the SWMD is assigned to each debris truck at the motor loader chowki.

In Ward K-West a private contractor has recently been engaged for debris removal on a regular basis. The contract includes the provision of one conventional truck with 4 loaders per truck. The vehicles report at the motor loader chowki in the morning and tasks are assigned to the crews by the JO. Payment is based on measurements of the loading capacity (Rs 35/- per m^3) which is recorded at the check point before the trucks leave to the disposal site where the load is again recorded. According to the contract arrangements debris is usually disposed of at landfill sites. Discussions with the contractor indicated that between two and three truckloads of debris are collected per day. The system seemed to be operating smoothly but the contractor said he wished that double checking of vehicle loads could be avoided.

The Building Department normally requires a security deposit from anyone applying for a building permit; the value of the deposit is Rs 250/-. The purpose of this deposit is to ensure that the builder takes responsibility for the removal of debris. Unfortunately, the Building Department normally does not inform SWMD when the builder requests the return of his deposit and so the security deposit is released, resulting in free removal of debris by the private contractor on behalf of the SWMD.

SUGGESTION: Manual loading of debris is hard work but does not pose special health risks on the labourers, apart from the risks associated with handling heavy and dusty materials. Therefore the present practice of using standard trucks (manual loading and unloading) seems acceptable as long as it is more economical than using special purpose vehicles. The involvement of private contractors seems appropriate and satisfactory in

operation. It is suggested that appropriate procedures for making the generator of the debris pay should be developed. The present system of charging a security deposit for building applications could provide a solution if this system were enforced and if adequate co-operation between the Building Department and the SWMD could be achieved.

A-4.2 INVOLVEMENT OF THE PRIVATE SECTOR IN SWM

A project which involves the private sector in solid waste collection has been introduced at Juhu Beach recently. (Juhu Beach is a very popular recreational area which attracts large numbers of visitors every evening, and there are a number of luxury hotels in that area.) Interviews with the public indicated that this programme was very successful and that the cleanliness of the beach had improved considerably since the private sector took over.

Based on information obtained from the SWMD, the private contractor employs 36 sweepers to clean the strip of beach, which is about 3,5 kilometres long. Cleaning is carried out in two shifts (23 sweepers in the morning shift from 6.30 am to 1.30 pm and 13 sweepers in the evening shift from 1.30 pm to 8.30 pm). The contractor is responsible for the collection of litter and its transport to community bins or collection spots from where loading and transport is carried out by the public sector, using two tractors with trailers of the SWMD or open trucks.

According to information obtained by the SWMD the contractor's costs are lower than the previous expenditure of the SWMD for carrying out the same service. To avoid problems with the Unions the contract has been arranged by a private association of hoteliers and citizens.

SUGGESTION: As with refuse transport it is suggested that the private sector should become more and more involved in primary collection of refuse, including street sweeping and drain cleaning activities. This may be the most promising approach to reduce the costs involved in this sector and to extend and improve services at affordable cost. A citizen who knows Bombay well suggested that an area surrounding the Cooper Hospital may be suitable to try out the privatisation of primary collection, street sweeping and drain cleaning services. It has been proposed to use this area for the project on a trial basis and to redeploy the existing staff in adjoining areas.

A-5 LEGAL PROVISIONS, ENVIRONMENTAL ISSUES AND ENFORCEMENT

Legal provisions, environmental issues and enforcement aspects are divided into three sections, namely (5.1) municipal waste and littering, (5.2) hazardous waste and (5.3) solid waste disposal.

A-5.1 MUNICIPAL WASTE AND LITTERING

Sanitation and solid waste are covered in Chapter 15 of the BMC Act (1888). This act was formulated in 1888 and since then the provisions relating to SWM have not been amended. Sections 365 to 378 of Chapter 15 are concerned with sanitary provisions relating to solid waste management (unauthorised littering, nuisance etc. - sections 313(A), 313(B), 313(AA), 368, 372(c) and 373) and include the penalty for violation under section 471.
However, following discussions with HO Dr. Dalal, DCE Shri Panjwani and Deputy Law Officer Shri Mathai, it was revealed that not in a single case had a prosecution under this chapter been launched in the court.

Three nuisance detectors (ND's) are employed in K-West Ward and empowered under the Bombay Police Act (BP Act) to apprehend nuisance creators and take them to the nearest police station for prosecution by the police. Apart from these ND's no other staff in the Health Department or SWMD of the Ward Office are taking any action against offenders of the BMC Act. Every one seems to take for granted that the ND's, who are hardly educated regarding this issue, are sufficient to prosecute offenders for creating nuisance in the streets, but this may well not be the case.

SUGGESTIONS

- The BMC Act, formulated in 1888, is an antiquated act and should be updated as soon as possible. Penalties and fines for violating the provisions of the Act are considered far too low to be effective. What is needed is a revision of the fine for infringement of Sections 368, 370, 371, 372, 377. Fines of Rs 20/- and Rs 50/- should be increased to between Rs 200/- and Rs 500/- (for severe cases such as tipping of debris on public ground). The provision of a further fine of, say, Rs 500/- per day for continuing offences should be included.

- The present system of enforcement of the regulations by ND's is considered totally inadequate. It is suggested that consideration be given as to whether AHS, supervisors and JO's should be given the power to challenge nuisance creators under the BMC Act (amended). It may be further considered to provide officers at the level of WO with legal powers to compound persons found violating provisions of the BMC Act. The Bombay High Court could be requested to confer the powers of Presidency Judicial Magistrate on DMC's to try offences under the BMC Act. The effects of such changes could be monitored by the High Court and Municipal Commissioner.

- Another alternative may be to provide power to supervisory staff of SWMD to challenge offenders under the BMC Act and prosecute them in the court of the Presidency Magistrate. However, judicial magistrates are very busy with civil and criminal work and probably do not have enough time to cope with municipal work. Being a municipal official, the DMC would probably appreciate sanitary and environmental hazards in a better way. In addition he/she may be able to devote more time to this work.

A-5.2 HAZARDOUS WASTE

The BMC Act (1888) does not recognise hazardous waste as a separate category. Specific obligations for disposal of solid waste by industries and hospitals are mentioned in general terms in the Act. However, as already mentioned in (i) above, the BMC Act is antiquated and enforcement of the panel sections is almost non-existent. In addition the level of fine for the infringement of the law is far too meagre to be a deterrent to prospective offenders, and enforcement by lower functionaries (i.e. JO's to AHS) is almost non-existent.

The Environmental Protection Act (EP Act) 1986 defines hazardous waste and provides rules for the handling of hazardous wastes (management and handling rules, 1989). These include rules for disposal sites, including licensing and monitoring of disposal sites by the State Pollution Control Board. However, these rules are not strictly enforced. Industrial premises are inspected by officials of the Pollution Control Board (PCB) once in a year. It was mentioned that the officials are well qualified and adequately trained to do their job.

According to the BMC Act industrial premises are supposed to deposit their waste in the community containers provided to the public, on a payment basis. Charges are fixed at Rs 8/- per 15 kg and JO's are responsible for assessing the weight arising from each industry. However, enforcement of payment is virtually impossible and most industries deposit their waste in the public containers, located outside their premises, without any payment. According to information obtained at the main landfill site, some industries deliver their waste directly to the site; about 50 truckloads per month were said to consist of industrial waste.

A similar situation exists in respect of clinical wastes. The BMC Act does not provide regulations regarding clinical waste and its handling, storage, and treatment.

In K-West Ward only one private hospital (Nanavati Hospital) was operating an incinerator; it was being used to incinerate about ½ ton of clinical waste daily. (This waste did not include plastic and glass bottles, which were recycled).

It has been observed that removal of solid waste from municipal hospitals is under the responsibility of the matron. Unfortunately, she may not have much of the say in decision making so solid waste collection and disposal have the lowest priority in hospital management. Although some training had been provided to the cleaning personnel and the matron, no protective clothing or equipment had been provided to any of the waste handlers, and the disposal facilities at or near the hospital were far from satisfactory.

Small nursing homes seem to be ignorant of the dangers of clinical waste. It has been observed that wastes from these premises are disposed of along with general domestic refuse.

Extracts of the laws pertaining to clinical and industrial waste are presented in Appendix AA-VII

SUGGESTIONS

- Based on the EP Act 1986, appropriate provision in the BMC Act should be made regarding the handling, storage, treatment and disposal of industrial and clinical waste. This should further include regulations for the transport of hazardous waste and appropriate amendments to the motor vehicle rules regarding the type of vehicle used, warning of any hazards and training of the drivers. Close co-operation between the SWMD and personnel of the PCB is considered crucial for enforcement of the regulations.

- Regarding handling of clinical waste it is suggested that control and enforcement should become the responsibility of the Ward Office. A more adequate system for clinical waste may achieved by using of different coloured and labelled bags for different waste categories (e.g. red bags for infectious clinical waste and yellow bags for non infectious clinical waste). In addition, fully-enclosed storage facilities should be introduced for storage of clinical waste. Finally, the personnel of the SWMD who are handling clinical waste, should be provided with adequate protective clothing and equipment.

- It is necessary to develop an adequate incineration capacity for clinical waste arising in all hospitals and clinics (private and municipal). Also required are adequate standards for transport of clinical waste to one or probably several central hospital waste incinerators, and a licensing system for transport contractors.

- Adequate training of hospital personnel in respect of clinical waste handling is considered crucial. Such training should be mandatory for responsible personnel from all medical establishments, including private hospitals and clinics). The CTIRC could probably become involved in the training of these personnel.

A-5.3 DISPOSAL OF SOLID WASTE

Pollution control is covered in the EP Act 1986 and rules are made thereunder (i.e. the Water Act 1974 and the Air Act 1981). However, there is no regular monitoring of disposal sites with regard to these laws, neither by the PCB nor by MCGB. The question of pollution by landfill leachate did not seem to have arisen at all, and the pollution of land seems to have very low priority.

There was an opinion within the PCB that enforcement by the State PCB had been quite inadequate and the procedure for prosecution was quite laborious. For example, infringement of the Air Act was caused by a fire at Deonar Dumping Ground and this pollution was the subject of a recent letter to CE (SWM). This letter did not include any advice on what ought to be done to avoid violation of the Act.

SUGGESTIONS

- Regarding municipal waste disposal facilities, it is suggested that the MCGB should be obliged to obtain licences from the PCB for operation of landfill sites. Within this procedure the PCB may become responsible for monitoring the pollution caused by the sites (e.g. groundwater and air monitoring).

- Adequate treatment and disposal standards should be developed for industrial waste according to different waste categories (which need to be defined). Licensing of facilities is considered a pre-requisite to the achievement of acceptable standards. Adequate disposal charges for the different categories of industrial waste should be introduced.

A-6 FINANCES

According to information from the Central Office the total annual expenditure on SWM in Bombay was Rs 126.67 crores (Rs 1266.7 millions) in the year 1991. This is about 14% of the total expenditure of the MCGB. Out of this about Rs 78 crores was spent on establishment (wages and salaries) and Rs 26 crores on solid waste transportation (contractors' and municipal vehicles). In addition about Rs 1.93 crores was spent for new works and equipment.

In addition, each ward receives Rs 10 lakhs which is spent at the behest of the elected councillors. It was mentioned in the Ward Office, however, that most of this money was spent on public paths, water supply, street lighting and the provision of parks. In K-West Ward not even a single item pertaining to SWM has been taken up by the councillors. This indicates that solid waste management is given quite low priority in the eyes of the decision-makers.

An estimate of the cost of removing Bombay's refuse each day, and other relevant data are shown in Appendix AA-IV.2.

About 73% of the total expenditure for SWM is spent on wages and salaries of staff. As already mentioned in section A-3.3-(iii), the performance of municipal labour is poor and considerable cost savings may be possible in this sector. On the other hand the expenditure on new works and stores (equipment) is just 1.1 % of the total SWM budget. As the establishment charges are fixed throughout the year and cannot be reduced, budget constraints generally lead to a cut in new works and vehicles, proportionately across the board.

Capital expenditure on machinery is usually based on a cost benefit analysis, carried out in the Central Office. However, it appeared that there had been no detailed study and analysis before an order for 70 new compactor vehicles of the 'Multipack' System had been placed. Regarding the need of funds for capital expenditure, it is shown in Part B that the storage capacity of community containers is totally insufficient and that additional funds are needed to cope with this deficiency.

The income realised from charges for the collection of trade waste were about Rs 3.6 crores in 1991 - less than 3% of the total expenditure on SWM. According to the DCE/SWM there are no arrears because outstanding charges are paid at the time of renewal of licences.

It has been suggested that the public who live in the areas where house to house collection services are provided would be willing to pay service charges .

SUGGESTIONS

Considering that about 73% of the total expenditure on SWM is spent on wages and salaries, it is considered crucial to improve the performance of labour (see section A-3.3). This would allow a substantial reduction in establishment costs. Savings could be used for upgrading the solid waste collection, transport and disposal system. Possibilities for achieving such a reduction may include a ban on fresh recruitment for vacancies arising out of promotions, retirements etc. for a period of at least five years (see Section A-3) and an increase in the involvement of the private sector in solid waste collection services (see section A-4). This would probably enable the reduction of the establishment costs to about 50% of the total expenditure gradually over a period of 5 years and unlock about Rs 3 crores annually).

- To increase the income generation of the SWMD, charges for house to house collection services could be introduced. In addition, improvements of collection and disposal standards for industrial waste could be achieved by charging for the services and by proper enforcement of regulations (see section A-6 above). Another potential area for cost savings may be the field of construction debris removal. It is considered possible to achieve cost recovery by introducing adequate charges for debris collection (see section A-4) in conjunction with an amendment of the BMC Act regarding fines and the introduction of adequate enforcement measures.

- As discussed in section A-3.5 the lack of publicity and public awareness campaigns is one of the most significant shortcomings in respect of solid waste management in Bombay. The activities described in section A-3.5 may help to make cleanliness the people's programme and therefore lead to a more healthy and clean environment at a comparatively low cost.

- Finally, it is suggested that SWM officers should interact with and lobby Municipal Councillors, MLA's and MP's to urge them to give a higher priority to solid waste management. Together with the activities of the PRO this may result in a higher allocation of resources due to an increasing public interest in the SWM sector.

A-7 CONCLUSION

Urban migration is beyond the control of MCGB and the civil amenities are already stretched to a maximum. The municipal authorities are trying their best to cope with the SWM problem. In K-West Ward the population has increased by 50% during the last decade, while the infrastructure provided for solid waste management has remained at basically the same level and the service quality has not improved in line with public expectations.

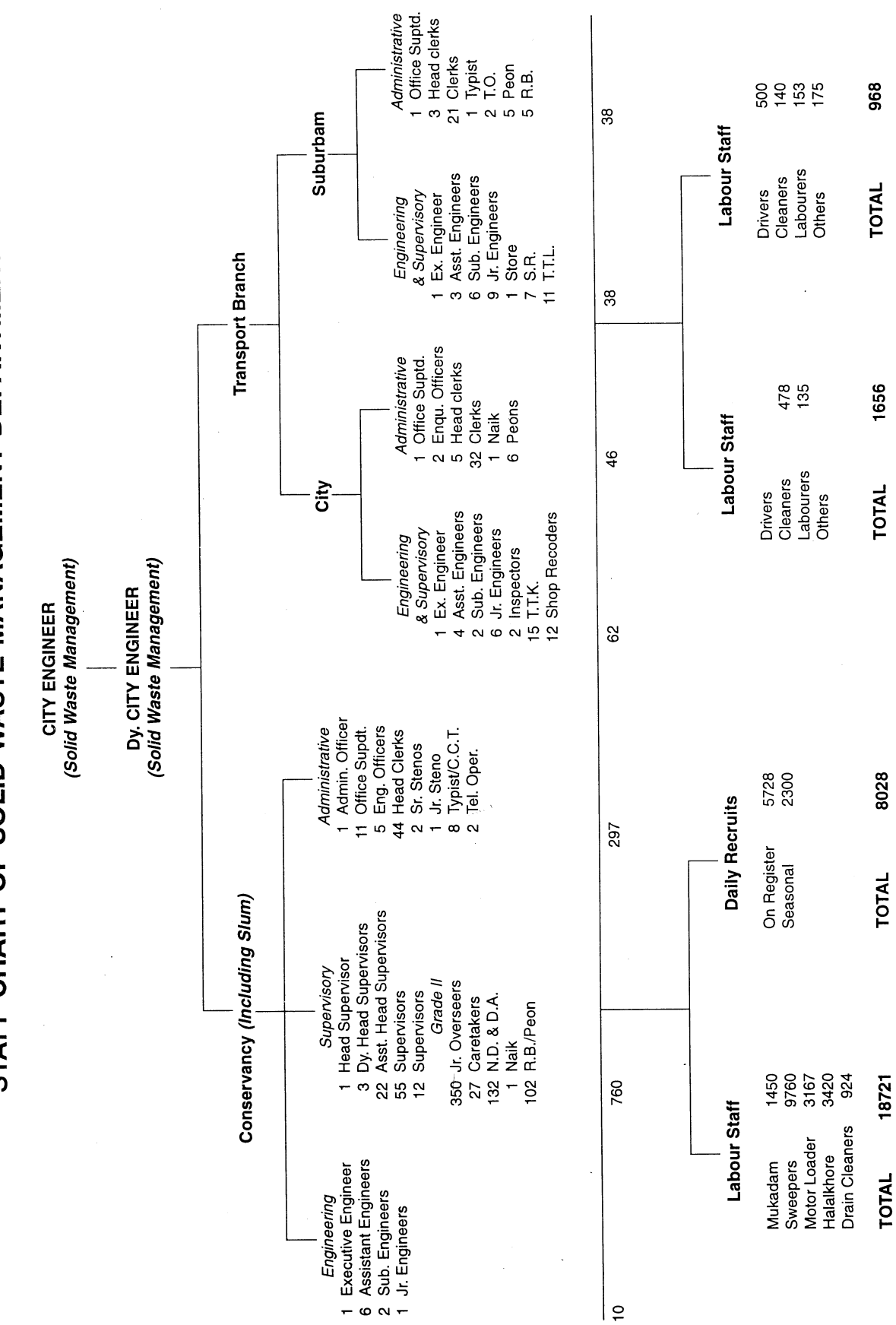
It is hoped that the suggestions outlined in this document may help to provide better solid waste collection services to the citizens of Bombay and to reduce environmental pollution caused by inadequate handling and disposal of waste.

PART A

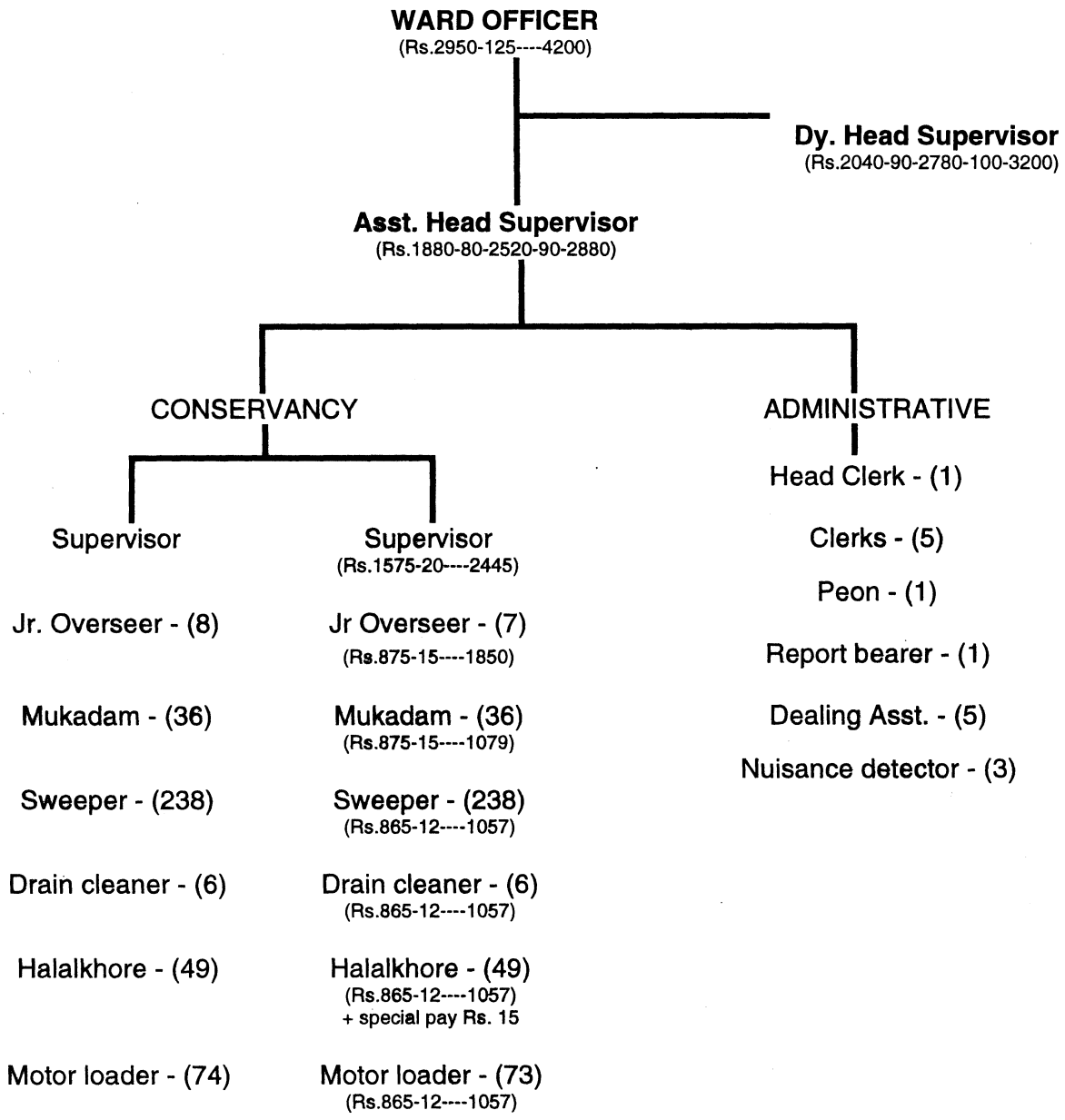
APPENDICES

APPENDIX AA-I.1

ORGANISATION CHART
SOLID WASTE MANAGEMENT DEPARTMENT
MUNICIPAL CORPORATION OF GREATER BOMBAY



APPENDIX AA-I.2 **ORGANISATION CHART**
SOLID WASTE MANAGEMENT DEPARTMENT
K-WEST WARD



APPENDIX AA-II PROFORMA FOR USE BY JUNIOR OVERSEERS

WARD: DATE:
Shift:

Name of JO

No. of sweepers absent

No. of sweepers absent half day:

No. of halalkhores absent:

No. of halalkhores absent half day:

No. of dust bins not cleaned:

No. of vehicles required but not available (received short) in his section:

No. of vehicles breaking down during shift:

No. of public toilets and urinals not cleaned:

Bin locations where refuse is overflowing:

No. of complaints received:

No. of complaints attended:

Signature: .....

APPENDIX AA-III SUGGESTED TRAINING PROGRAMMES

TRAINING PROGRAMME FOR SWEEPERS AND HALALKHORES

1st DAY
1. Introduction to SWM Organisation
2. Personal & social hygiene
3. Audio visual presentation on unhygienic localities

2nd DAY
1. Use of different equipment in SWM
2. Salient features of sanitary provisions in the BMC Act
3. Audio visual presentation on clean localities

3rd DAY
1. Public participation in SWM
2. Do's and don'ts in SWM
3. Audio visual presentations on diseases, vectors and rodents

TRAINING PROGRAMME FOR SUPERVISORS

1. - Introduction to management
   - Management techniques
   - Manpower management

2. - Definition of solid waste and environment pollution
   - Importance of good solid waste management
   - Planning and management

3. - Refuse collection systems
   - Financial aspects of SWM
   - Supervision

4. - Reporting techniques

APPENDIX AA-IV.1

TYPICAL TOTAL SALARY CALCULATION

	Rupees
Basic pay	1007
Dearness allowance (Inflation in cost of living)	1181
Compensatory allowance	49
Washing charges	15
Medical allowance	27
Interim relief A	117
Ad hoc additional pay	50
Total salary	2446

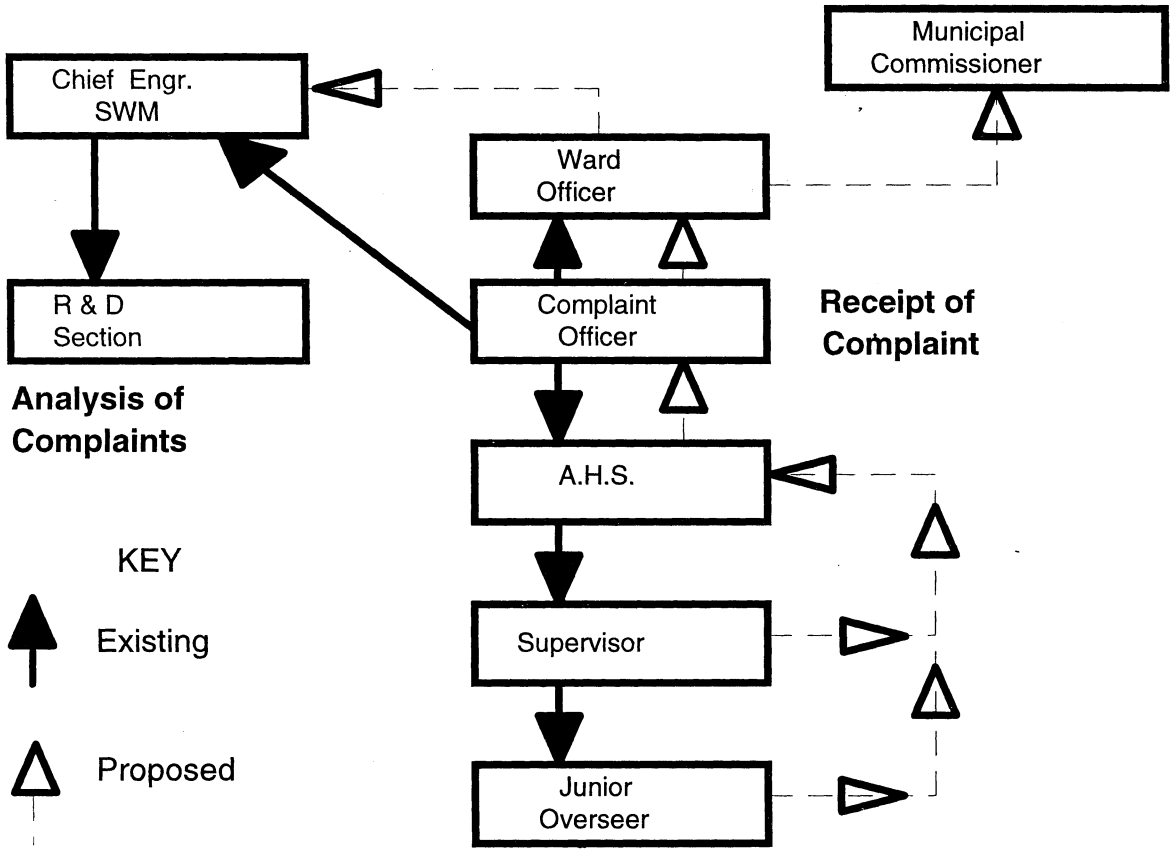
Motor loaders are allowed the following days of leave each year:

20 days medical leave
33 days earned leave
20 days casual leave
52 days - weekly day off

APPENDIX AA-IV.2 RESOURCES INVOLVED IN REFUSE COLLECTION AND TRANSPORT

Ward	No. of lorries used for removal of refuse per day (lean season)	Weight of refuse removed per day (tonnes)	Daily expenditure for removal of refuse (Rupees)	No. of lorries used for removal of debris per day (lean season)	No. of house gullies	Total staff
A	46	212.45	83,250	6	518	1692
B	26	119.52	50,700	4	936	1384
C	47	254.20	88,200	6	1852	2091
D	22	369.60	139,950	6	1375	2452
E	64	306.52	114,750	6	1005	2520
F/south	34	191.35	61,200	5	114	1161
F/north	33	151.23	47,250	5	-	1105
G/south	39	249.16	78,750	6	135	1359
G/north	46	232.39	76,950	8	91	1869
H/east	21	111.13	37,800	4	-	794
H/west	38	196.19	48,600	4	-	980
K/east	27	163.06	45,450	4	-	959
K/west	34	196.61	47,250	4	-	1124
P/south	13	76.18	28,350	4	-	634
P/north	17	78.32	45,450	4	-	777
R/south	13	76.13	29,700	3	-	445
R/north	23	152.10	31,500	4	-	746
L	26	153.55	32,850	8	-	772
M/east	17	85.42	23,400	3	-	300
M/west	19	103.55	23,400	5	-	792
N	17	91.16	32,850	6	-	833
S	17	102	29,700	4	-	542
T	12	64.52	22,050	3	-	555
	697	3,746.25	1,210,350			10,223

APPENDIX AA-V FLOW CHART SHOWING EXISTING AND PROPOSED COMPLAINT MONITORING SYSTEM



APPENDIX AA-VI

ESTIMATE OF COST OF PROTECTIVE EQUIPMENT FOR MANUAL LABOURERS

No of motor loaders (in city and suburbs including women)..... 4289

No of halalkhores (in city and suburbs including women) 1596

Total No of sweepers and halalkhores: 5885

Cost of equipment for one person: Rs 150/= each

Total cost of the equipment = 8.83 lakhs, keeping for reserves and defective supplies it could be rounded to Rs 10,00,000.

APPENDIX AA-VII EXTRACTS OF LAWS PERTAINING TO CLINICAL AND INDUSTRIAL WASTES

368 (A)

Sub Section (1)
It shall be incumbent on the owner (directors and managers of the company) of hospitals, nursing homes and clinics to dispose of by incineration all their clinical waste in an incinerator approved by MCGB. In case of use of such facilities of others, they shall be changed at the rate approved by MCGB.

Sub Section (2)
It shall be incumbent on the owner (including directors, managers) of industries to cause all ashes, refuse, rubbish, acid, and industrial waste - including liquid, acid, gaseous wastes - to be collected from their respective premises and to be deposited on payment of charges fixed by MCGB at a licenced facility run by MCGB.

Explanation
Clinical waste means waste contaminated with blood, secretions, excreta or any other matter which can cause infection e.g. amputated organs, placenta, acid, dressing material etc.

PART B

PRIMARY COLLECTION AND STORAGE IN K-WEST WARD, BOMBAY

LIST OF CONTENTS — Page

B-1 INTRODUCTION

This part discusses the management of solid waste until the stage when it is loaded into a vehicle to be transported to the disposal site. It is concerned with sweeping, drain cleaning and storage, and, to a lesser extent, public toilets.

B-2 PRIMARY COLLECTION AND STORAGE OF SOLID WASTE IN K-WEST WARD

B-2.1 ORGANISATION

The organisational set up of the Solid Waste Management Department (SWMD) in K-West Ward has already been described in Section A-2.2.

Street sweeping, drain cleaning, cleaning of public latrines and urinals, and maintaining cleanliness around the community storage facilities provided by the SWMD are together classified as *conservancy services*. With regard to these services, K-West Ward is divided into two administrative zones (northern and southern). These zones are further divided in 13 SWM districts (five in the northern and eight in the southern zone). One Junior Overseer (JO) is assigned to each district to organise the work of the conservancy staff of the SWMD. The organisational set up of the conservancy section in Ward K-West is shown in Table B-2.1 below.

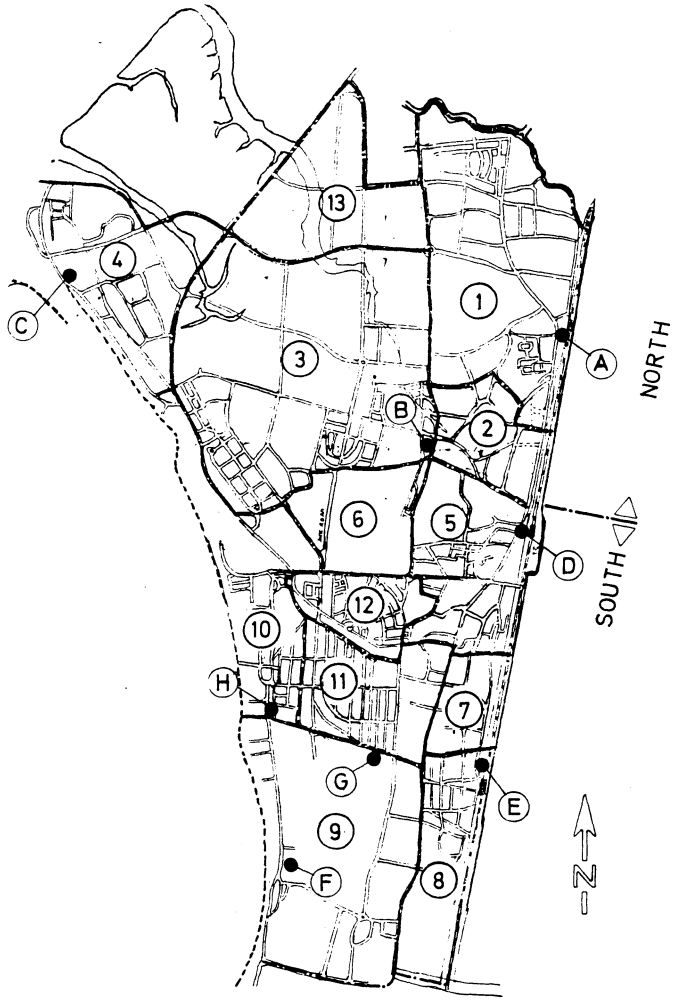
Table B-2.1: Organisation Chart of the Conservancy Section

One Assistant Head Supervisor (head of SWMD in Ward K-West including conservancy services)	
Two Supervisors (one supervisor per zone, responsible for SWM including conservancy services)	
13 Junior Overseers (in charge of organisation and supervision of conservancy services in the 13 SWM districts)	Junior Overseers (Motor loaders)
33 Mukadams (foremen of conservancy staff, supervision of labour twice daily, between 2 and 3 mukadams per JO)	Mukadams for motor loaders
662 Labourers (about 20 labourers per mukadam)	147 motor loaders

498 sweepers (sweeping roads cleaning lanes in public areas and government slums)	29 drain cleaners (cleaning of roadsand small drainsin public areasand governmentslums)	135 halalkhores (cleaning of public toilets removal of faeces from public areas and in government slums)

Conservancy services are carried out seven days per week. The official working hours are from 6.30 am to 1.30 pm (seven hours per day including a tea break from 10.30 to 11.00). Labourers work six days per week and have one day off (in turn).
For the day to day organisation of work there are eight muster chowkies (Junior Overseer Offices) in Ward K-West as shown in Figure B-2.1.

Figure B-2.1: SWM Districts and Muster Chowkies in Ward K-West



LEGEND

MUSTER CHOWKIES:
A Jogeshwari
B Rajkumar
C Versova
D Andheri Station
E Parla Station
F Juhu South
G Mithibai College
H Juhu North

SWM DISTRICTS:
1 Jogeshwari
2 Rajkumar (East)
3 Rajkumar (West)
4 Versova
5 Andheri Station
6 Andheri Slum
7 Vileparle (North)
8 Vileparle (South)
9 Juhu Section (South)
10 Juhu Section (North)
11 Juhuscheme (South)
12 Juhuscheme (North)
13 Lokand Valla Complex

Municipal sweepers, drain cleaners, halalkhores and mukadams meet at these chowkies at 6.30 in the morning. Attendance is taken by the JO and particular tasks are assigned to the labourers before they leave the chowki to start their work. Each SWM district is further divided into beats for street sweeping and street sweepers are permanently assigned to these beats. The total number of beats is Ward K-West is about 262.

Depending on the time taken to walk from the muster chowki to the places of work, the staff actually start working between 7.00 am and 7.15 am.
Towards the end of the working day attendance is again taken at the muster chowki (at about 1.15 pm). In order to reach the muster chowki in time, labourers have to leave their places of work between 12.45 and 1.00 pm.

Considering that there is a tea break from 10.30 to 11.00 the effective working time of labour is between 5 and 5½ hours per day. It will be shown in section B-3, *Operations in Jogeshwari SWM District*, that the actual working time of labour is even lower than the values mentioned above.
It is shown in Figure B-2.1 that there are only eight muster chowkies in the ward compared with 13 SWM districts. For instance the muster chowki at Rajkumar has to accommodate 3 JO's and the chowkies at Parla Station, Mithibai College and Andheri Station accommodate 2 JO's each. Consequently, about 150 labourers meet at the Rajkumar chowki in the morning and about 100 in the other three chowkies mentioned above.

Although organisation of the day-to-day duties may be possible, the distances that the labourers must walk to arrive at their places of work are excessive. In the worst case labourers are required to walk about eight kilometres, twice daily (for morning and noon attendance). Therefore the effective working time of labour, which is already very short (between 5 and 5½ hours per day), is further reduced in these areas.

SUGGESTION: It is therefore proposed to provide one muster chowki for each of the SWM districts (i.e. five additional muster chowkies in Ward K-West). Further investigations are required to identify suitable locations for these chowkies. As shown in Figure B-2.1 some of the existing muster chowkies are located at the fringe of the SWM districts. To ensure that the walking distances from the chowkies to the places of work are kept to a minimum, it would be highly desirable to locate muster chowkies near the centres of the SWM districts.

B-2.2 CONSERVANCY SERVICES IN K-WEST WARD

The services provided by the public sector in Ward K-West are described briefly in this section. This includes street sweeping in (i), drain cleaning in (ii) and cleaning of public latrines in (iii). Some more general considerations are suggested in this context. More detailed observations are presented in sections B-3 and B-4.

(i) Street sweeping

As already mentioned above, the ward is divided into SWM districts which are further split into beats (about 262 in K-West). Within the SWM districts sweepers are assigned permanently to particular beats. According to information obtained from the Chief Engineer SWM (CE/SWM) the average area of roads and lanes within one beat is between 3,000 and 5,000 square metres in busy areas (e.g. along main roads), and 5000 to 10,000 square metres in quieter areas (e.g. along secondary roads).

One pair of sweepers is assigned to each beat for sweeping and cleaning the roadside and the areas surrounding the community containers. It has been observed that, of the two sweepers in a team, only one of the sweepers sweeps along the roadsides and in the lanes. He forms small heaps of sweepings along the kerb and it is the second sweeper's task to load these piles into his handcart and carry them to the nearest community container. The central section of the road is not swept and there is no need to do so because dust and litter are blown by moving traffic towards the side.

This arrangement is analysed in detail in section B-3.3. However, some general observations are noted here.

SUGGESTIONS

- Information obtained from officers of other municipal corporations in India suggests that it is quite unusual to require sweepers to work in pairs. Further observations should be made to compare the system of sweeping in pairs with the more common single sweeper system (see Section B-3.3).

- It has also been suggested that a night shift should be introduced for street sweeping in very busy streets. This proposal aroused different views when discussed by the groups and further investigations are suggested to investigate the need of this measure as well as suitable measures for implementing such a service. One outcome that was foreseen was that municipal staff, supported by the Unions, would probably demand 100% higher wages for working at night.

- Within this context the pros and cons of small mechanical sweepers have been discussed. Although this may avoid the need to sweep busy roads during the peak traffic hours, this type of machinery is not available in India and severe repair and maintenance problems are anticipated. However, further investigations are required and should include exchange of experience with other large municipal corporations regarding mechanical sweepers as well as a market research on suitable equipment. In any case small scale pilot projects are suggested before such systems may be introduced on a larger scale.

(ii) Drain cleaning

Drain cleaning in residential localities and along small roads is carried out by the 29 drain cleaners (DC's) in K-West Ward. However, according to information obtained from the SWMD, the Maintenance Department is responsible for cleaning and maintenance of large drains. It was mentioned that all drains larger than six inches (0.15 metres) are under the responsibility of the maintenance department. It was also mentioned that street sweepers become responsible for the cleaning of small drains along the roads and lanes when the drains are dry.

During drain cleaning by staff of the conservancy section silt heaps are formed along the drains and left to dry for a period of time. The heaps are then loaded into wheel barrows and carried to the closest community storage facility.

However, it has been observed that drains in Ward K-West are not cleaned regularly and that they are often used for refuse disposal by the public. Particularly in low-income areas, drains are clogged, causing flooding and unhygienic conditions. This will be further elaborated in section B-4, *Investigations in Slum Areas*. Some more general suggestions are set out below.

The arrangements regarding drain cleaning are considered inadequate. Responsibilities seem to be not clearly defined and different departments are involved in this sector. Considering that only 29 drain cleaners are employed by the conservancy section in K-West Ward, these personnel seem hardly sufficient to cope with all the work.

SUGGESTIONS

- Further investigations are proposed to identify suitable solutions in this sector. They should aim at providing a clear responsibility structure for drain cleaning services. Because of the fact that drain cleaning and street sweeping are interrelated, it may prove advantageous if the SWMD were to become responsible for *all* drain cleaning services in the ward. It may be most suitable to assign cleaning of the small drains to sweepers, i.e. drains in a particular beat should be cleaned by the street sweepers in charge of the area. However, cleaning of large drains will require separate crews who are equipped with appropriate implements. The assignment of labour to particular main drains may be the most promising arrangement, together with regular monitoring and supervision.

- Public awareness campaigns are considered crucial to discourage the depositing of refuse in the drains by the public (see Section A-3.5). This may further include the provision of additional community storage facilities in the areas concerned.

(iii) Cleaning of public toilets

Public toilets are the most commonly used in low income and slum areas in Bombay. Latrines on public land are cleaned by the conservancy staff of the SWMD (135 halalkhores). According to information obtained from the Ward Officer, certain private slums are served by private contractors (including the cleaning of public toilets).

Services performed by the municipal workers (halalkhores) include cleaning and disinfection of public toilets and removal of faeces from public areas. It has been observed, however, that public toilets are not properly cleaned and maintained and that children in particular are commonly seen defecating in front of the toilets and in areas adjacent to community refuse bins. This issue is discussed in more detail in section B-4, *Investigations in Slum Areas.* Results of a household survey (see Section B-4.4) indicate that the people in slum areas consider the cleaning of public toilets to be the most neglected service in their communities.

SUGGESTIONS

- The people in slum areas are not satisfied with the cleanliness of public toilets. Further investigations are required to identify suitable arrangements for toilet cleaning. Consideration should be given to increasing the involvement of the private sector in this field. Experience gained by the New Delhi Municipal Committee indicates that it may be suitable to employ private contractors for construction, operation and maintenance of public toilets.

- Public awareness campaigns are considered crucial to avoid indiscriminate defecation in public areas (see section B-4).

(iv) The role of private sweepers

Conservancy services undertaken by the public sector are generally not provided in private areas (which include 46 private slums and a large number of private residential complexes). However, according to information obtained from the Ward Officer, all of the large private residential areas as well six private slums are covered by sweepers on a private contract basis within pilot projects. It has been further mentioned that these projects are very successful and that another eight private slum areas will be included, beginning in 1993.

According to information obtained in one of the private slum areas (Bauder Ville), the monthly salary of private sweepers is Rs 535. Considering that the salary of municipal sweepers ranges between Rs 865 and Rs 1,057, the private sector is capable of providing sweeping services at a considerably lower cost.

SUGGESTION: As already mentioned in Section A-4, it is suggested that the private sector becomes more and more involved in primary collection of refuse, including street sweeping and drain cleaning activities in private and public areas. This may be the most promising way to reduce the expenditure involved in this sector and to extend and improve services at affordable cost. At present a large number of private slum areas remain without street sweeping services and therefore an extension of services might concentrate on these areas.

However, supervision of private sweepers could cause problems because these personnel may contribute to crude dumping of waste in the localities. Hence, provided that sufficient community storage facilities will become available, strict supervision would be required to ensure that private sweepers use these facilities properly.

B-2.3 PRIMARY COLLECTION OF REFUSE

The existing system of primary collection in high-rise and multi-storey buildings is described in section (i) below. In slum areas primary collection is usually carried out by the residents who carry their household waste to communal storage facilities or crude dumping areas in the locality. However, in some slum areas private refuse collectors, sometimes called private sweepers, are employed by the residents for house-to-house collection of refuse and to transport it to community containers [section (ii)].

(i) Primary collection of refuse in high-rise flats

Most of the middle and high income groups in Bombay live in high-rise buildings. Housing societies usually employ private refuse collectors (also called private scavengers or private sweepers) for daily collection of refuse from the flats and carrying it to the nearest community container.

Some people in high and middle income groups were asked about the situation in their household

Q-2: Who is responsible for taking out refuse from your house?

	Mother	Father	Children	Servant	Private sweeper
High income	0	0	0	9	6
Middle income	3	1	0	1	5

The answers confirm that refuse collection from high income groups is almost exclusively carried out by private collectors or house servants. It is further shown that this seems to be slightly different in the middle income bracket. However, the questionnaire was carried out in blocks with only three storeys and therefore a different situation is considered likely in high-rise buildings.

In addition some of the private collectors were interviewed. In one case two persons are employed by the housing society to collect the refuse from 150 flats in five different blocks. Refuse is collected door-to-door seven days per week.
Plastic bins with a capacity of about 60 litres are used by the collectors for storage and transport of domestic refuse, . According to information provided, the daily working time is about 6 hours and the salary is Rs 500 per collector per month. This is equal to about Rs 7 per flat per month. It has been further observed that the private collectors gain some additional income by recycling items that they separate from the refuse they collect. Recycling takes place at the community storage facilities before unwanted material is deposited in them. Recyclables are sold to hawkers and recycling shops.

In another case four private collectors were employed by a housing society to serve about 270 flats in 9 blocks. The salary of these people was only Rs 225 per month per collector (Rs 100 per block or about Rs 3.50 per flat).

Replies to a small questionnaire survey indicate that the residents are satisfied with the existing refuse collection service that is provided by private collectors.

The existing system of primary collection by private collectors is functioning well and works independently of the public sector. Although there may be possibilities of changing the present system (i.e. by providing refuse chutes in high rise buildings), this is not considered desirable as long as the people are satisfied with the present arrangements. The monthly charges of about Rs 3.50 to 7 per flat seem to be affordable and the people are willing to pay for this service. Due to the fact that there is a large number of private collectors employed in Bombay this system also helps to create employment for the urban poor. Considering these factors no changes seem to be required.

(ii) Primary collection in slum areas

In several slum areas and single storey residential areas it has been observed that some of the residents employ private collectors to collect refuse from their households and take it to community storage facilities or crude dumping areas. According to the residents, the charges are about Rs 8 per house per month. The opinions of these residents about refuse collection in slum areas is further discussed in Section B-4. Some general conclusions and suggestions are set out below.

As is the case with high-rise flats, primary collection by private sweepers is considered to be the only possibility for providing house-to-house collection to low income groups. It would not be economically feasible for the public sector to provide such services. The system of private sweepers allows for flexible arrangements, i.e. the people can choose whether they want to pay for a more convenient house-to-house service or whether they prefer to carry their refuse themselves.

However, due to the fact that there is a lack of community storage facilities in slum areas, residents and private collectors commonly use crude dumping areas near where they live. Therefore the provision of sufficient community storage facilities in these areas is a pre requisite to achieving more sanitary conditions in these areas (see Section B-4). The introduction of more containers should be accompanied by public awareness campaigns and tight control of private collectors to ensure that these facilities are used properly.

B-2.4 IMPLEMENTS AND PROTECTIVE CLOTHING

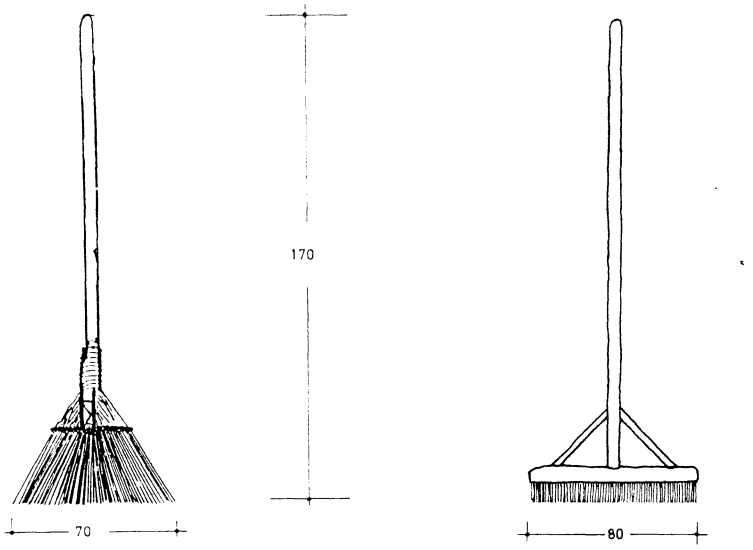
Sweepers, drain cleaners and halalkhores are the cutting edge functionaries of the conservancy unit. Therefore it is of utmost importance to provide them with adequate equipment to enable them to work efficiently and with minimal health and safety risks. The different types of equipment used at present are discussed in this section. They include (i) brooms, (ii) different types of handcarts and baskets as well as wheel barrows and (iii) protective clothing.

(i) Brooms

Each pair of sweepers is equipped with a standard broom as shown in Figure B-2.2.(a). When the brooms wear out they are repaired by the sweepers using the spares for broom repairs kept at the muster chowki. This type of broom is versatile regarding sweeping on rough and paved surfaces. Based on discussions with sweepers they like the design and handling of the standard broom.

A wide based long handle type of broom has been suggested for sweeping long stretches along main roads (see Figure B-2.2.(b)). However, this type of is more expensive than the

Figure B-2.2: a) Standard broom **b) Wide base broom**

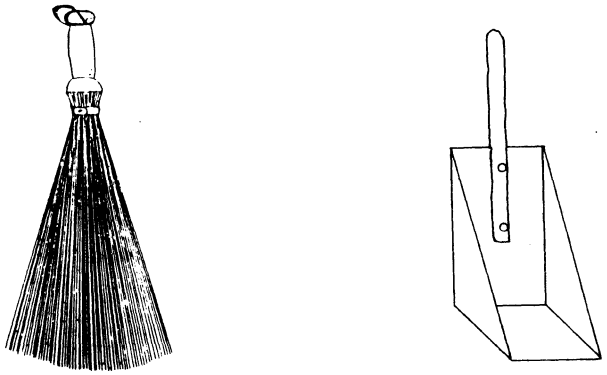


standard type and more difficult to repair. In addition this broom cannot be used in areas with a rough surface. It may prove suitable, however, to introduce the wide based type in beats which involve sweeping of large, paved areas.

For loading of the sweepings two small wooden boards (with dimensions of about 20 cm by 30 cm) are kept by the sweepers who are responsible for loading. One of the boards is held in each hand and the sweepings are squeezed between the boards for lifting and loading into the handcart. It has been observed that the sweepers are very skilful in handling the boards and that even sandy particles are lifted in no time. Although these boards are not provided by the SWMD each of the sweeper crews that was observed had equipped themselves with a pair. Some of boards were almost worn out, which indicates that they had been used for a long time and were considered to be a valuable tool.

It has been suggested that kerosene cans in conjunction with a small broom should be tried as an alternative, as shown in Figure B-2.3. However, there appears to be no real need to change the present system.

Figure B-2.3: Kerosene can and small broom for loading sweepings



SUGGESTION: Standard brooms are considered suitable for sweeping purposes. A wide base broom could be introduced on a pilot basis in beats which involve the sweeping of large, paved areas. Monitoring of the system is suggested to find out whether this will allow an improvement in the efficiency of the sweepers. A trial to investigate the benefits of introducing a modified loading system for street sweepings - as shown in Figure B-2.3 - might be worthwhile.

Due to time constraints the group did not observe the equipment used by drain cleaners and halalkhores. Further observations would be required to assess these implements.

(ii) Handcarts and baskets

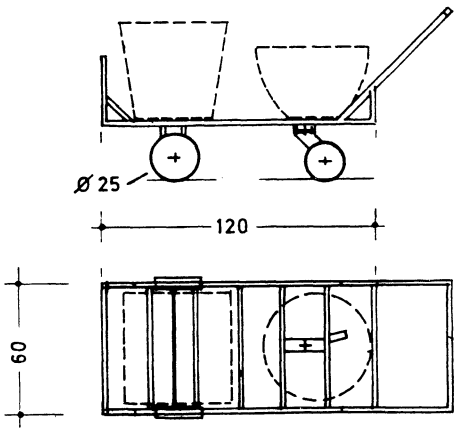
There are two main types of handcarts used in K-West Ward as shown in Figure B-2.4 and B-2.5. Both are equipped with baskets as described below. In addition there are some wheel barrow type handcarts as shown in Figure B-2.6. The number of handcarts employed in K-West Ward in relation to the conservancy staff is shown in Table B-2.2 below.

The table indicates that there seems to be a shortage of handcarts in K-West Ward. Considering that some spare carts are also required, (about 10 % may be sufficient), to allow for repair and maintenance, the number of handcarts required would be about 375, whereas the existing number of handcarts is only 312.

Table B-2.2: Handcart requirements in Ward K-West

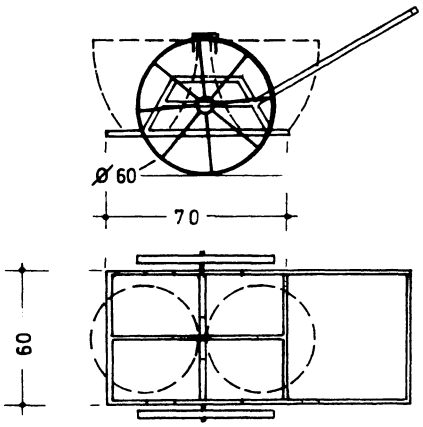
Existing handcarts			
	Type A, 3 wheeled	see Figure B-2.4	156
	Type B, 2 wheeled	see Figure B-2.5	138
	Type C, wheel barrow	see Figure B2.6	18
	Total existing		**312**
Required handcarts			
	For street sweeping	about 262 beats	262
	For drain cleaning	about 14 crews	14
	For toilet cleaning	about 64 crews	64
	Total required		**340**

Figure B-2.4: Type A handcart



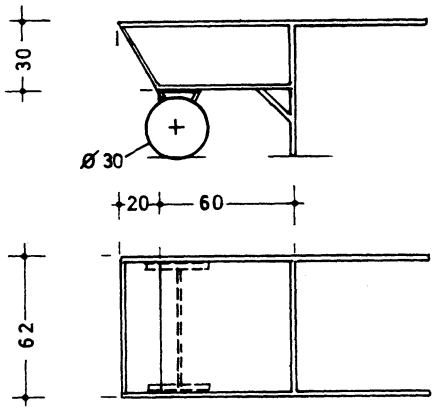
This cart is equipped with two fixed wheels and one pivoting wheel at the handle end. It is shown that small diameter wheels are used, therefore movement on unpaved areas is hardly possible. However, the cart is easy to push and manoeuvre on paved roads and lanes. Since sweeping is almost exclusively carried out along paved roads the design of the type A cart is considered appropriate for this purpose . It is simple, cheap and durable.
The cart is equipped with two baskets, made from cane or bamboo, each having a capacity of between 40 and 70 litres. Assuming that the density of street sweepings may be about 350 kg/m^3 and two 70 litre baskets are used, this handcart may carry up to 50 kg per load. The smaller cane baskets would allow a load of only about 30 kg.

Figure B-2.5: Type B handcart



The Figure shows the two wheeled type B cart. There is also a three wheeled version similar to the type A cart - i.e. with a small rotating wheel fitted at the handle side of the cart. It is shown that large diameter steel wheels are fitted to this cart, to facilitate pushing and manoeuvring operations on paved and uneven surfaces.
It has been observed, however, that the bearings of these carts wear out quickly. All of these carts were very old and so poor maintenance and probably inadequate design are the likely causes of the problem. The sweepers did not indicate a preference regarding the number of wheels (i.e. two or three).
As with type A carts, only two baskets of various capacities (40 to 70 litres) are loaded on this type of cart, therefore the weight carried is between 30 and 50 kg per load.

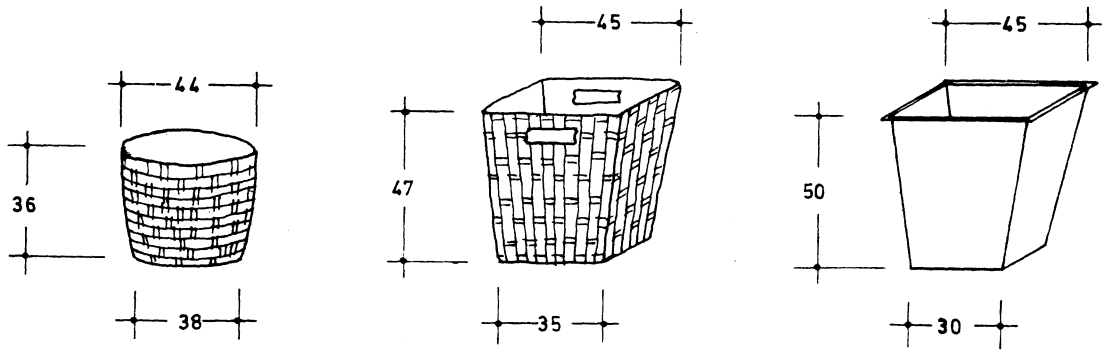
Figure B-2.6: Wheel barrow type cart



The wheel barrow type handcart is used for collection of street sweepings and for toilet cleaning. This cart provides a capacity of at least 130 litres (loaded level) and around 175 litres if fully loaded. A rubber rim is fitted to the small wheels and pushing and manoeuvring along paved roads and lanes is reasonably easy. If used for street sweeping a load of up to 60 kg could be carried and if faeces are carried the weight of a levelled load may be about 100 kg. Emptying into community storage facilities always involves double handling, i.e. tipping onto the ground and manual loading. Bin type carts are therefore more suitable and should be preferred.

Different types of baskets which are used on the handcarts described are shown in Figure B-2.7 below.

Figure B-2.7: Baskets and bins (used on handcarts)



CANE BASKET
(about 50 litres)

BAMBOO BASKET
(about 75 litres)

PLASTIC BIN
(about 70 litres)

It is shown in the figure that there is no standard design for baskets. The capacity ranges between 45 litres and 75 litres, some of the baskets are square, others round, most are made of cane and some of bamboo.

At present 50 litre cane baskets are primarily used. It has been reported that the life span of these baskets is only between two and three months and that they cost about Rs 150 per basket. Spare baskets are kept in the muster chowkies.

Some of the sweepers mentioned that bamboo baskets are far more durable than cane baskets. Figure B-2.7 shows a the design of a bamboo basket which is equipped with openings for easy handling.

Recently plastic bins have been introduced in some areas of K-West Ward. These bins have a capacity of 70 litres and cost about Rs 700 per bin. According to information obtained in the SWMD it is expected that these bins are more economical than cane or bamboo baskets due to their longer life span. Although these bins are not equipped with handles the projecting lip allows for handling to some extent. However, openings like the bamboo type would probably ease handling of these bins.

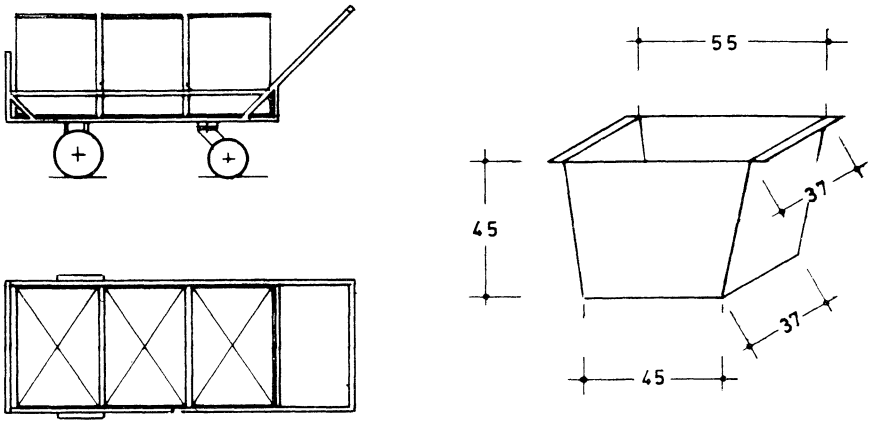
SUGGESTIONS

- As shown in Table B-2.2 above there seems to be a shortage of handcarts in K-West Ward. It is therefore suggested that further investigations be carried out in individual muster chowkies to identify the number of additional carts required. In Section B-3 the situation in Jogeshwari muster chowki is analysed in more detail.

- To avoid double handling it is suggested that the wheelbarrow type cart should be phased out as soon as possible. This type should be replaced by a handcart-bin system. In paved areas the type A handcart is considered appropriate, in areas with unpaved surfaces and slopes, carts with larger wheels are more suitable.

- It is further suggested handcarts, baskets and bins should be standardised. This may involve the introduction of different handcart designs on a pilot basis; the different types should be monitored in close co-operation with the sweepers and halalkhores. To achieve a more efficient handcart system the present capacity of between 30 and 50 kilograms should be increased considerably. Some suggestions are shown in Figure B-2.8 and B-2.9 below.

Figure B-2.8: Type A handcart with three plastic bins

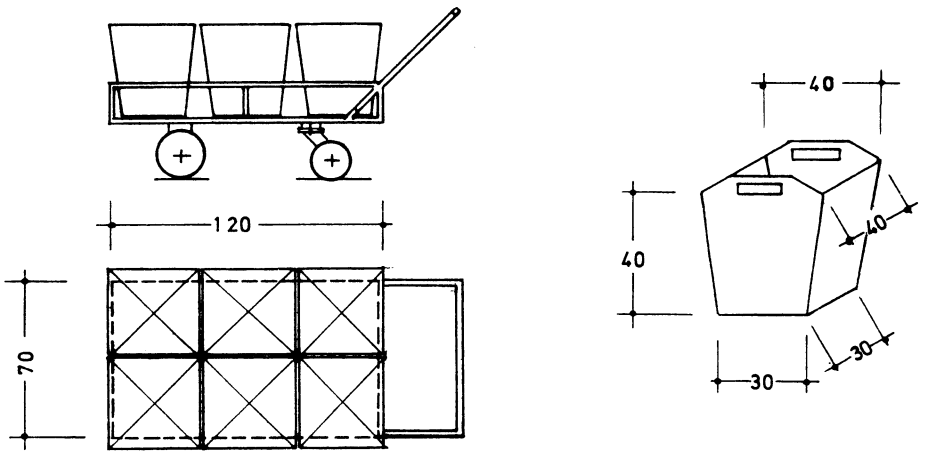


Results of the present pilot project with plastic bins may be used to decide on the most suitable material. It should be remembered, however, that plastic bins avoid spillage of dust and that they are suitable for transport of wet material like drain cleanings and faeces.

Three bins, with a capacity of about 70 litres each, would enable a cart to carry about 75 kg. This would increase the efficiency of handcarts considerably.

As a more long term objective it is considered desirable to introduce smaller bins which are easier to handle. Since there are many female sweepers, the total weight of a full bin should not exceed about 20 kg to allow convenient lifting and tipping into community storage facilities. Figure B-2.9 shows an arrangement of a slightly larger Type A handcart which is designed to carry six bins which have a capacity of about 50 litres each.

Figure B-2.9: Enlarged Type A handcart with six bins



This type of handcart would allow for loading at least 100 kg of street sweepings (which is more than twice as much as in the present system). In non paved areas the cart should be equipped with larger diameter wheels.

(iii) Protective clothing

As already mentioned in Part A, conservancy workers are not equipped with gloves, and no boots are provided to drain cleaners and halalkhores. Uniforms are considered important in an unhealthy working environment. They allow for some publicity and also ease supervision of labour. At present a new uniform is issued to the conservancy staff every second year. However, it has been observed in the Jogeshwari muster chowki that less than 50 % of the employees wear their uniforms while they are on duty. Reasons include that the present practice of providing only one uniform per person does not allow for washing and repair.

In addition there are no arrangements for regular medical check-ups. However, some sweepers mentioned that they arranged their own annual medical examinations.

SUGGESTIONS

- As already suggested in Section A-3.3, section (iv), conservancy staff should be provided with adequate protective clothing. Gloves could be cotton, woollen, leather, rubber or plastic. Keeping hygiene in mind, cotton and woollen gloves are ruled out. Rubber and plastic gloves are very warm and therefore resined or leather gloves may prove suitable. In addition long rubber boots should be provided to drain cleaners and halalkhores.

- It is further suggested that a thorough annual medical check-up should become provided for conservancy workers at no charge.

- To allow for washing and repair, it is suggested that two sets of uniforms should be provided to conservancy staff. This would make it possible to enforce the wearing of uniforms during official working hours.

B-2.5 COMMUNITY STORAGE FACILITIES

Solid wastes from households, commercial enterprises and institutions are deposited in the community storage facilities provided by the SWMD. In addition street sweepers, drain cleaners and halalkhores use these facilities for disposal of solid waste. The storage capacity provided in K-West Ward is analysed in (i) below and the different types of storage facilities are described in section (ii). Some aspects regarding the impacts of rag picking on the cleanliness of these locations are mentioned in (iii).

(i) Storage capacity of community facilities

The storage capacity of community facilities, based on information obtained in the SWMD is summarised in Table B-2.3.

Table B-2.3: Existing capacity of community storage facilities in K-West Ward

Type of facility	Capacity [m^3]	Number	Total capacity [m^3]	Emptying frequency [per day]	Storage capacity [m^3]
Steel pipe sections	about 0.7	203	142	once	142
Compactor trolleys	1.0	69	69	50% once, 50% twice	103
Masonry facilities	about 5	8	40	once	40
Refuse sheds	about 5	2	10	once	10
Total storage capacity in K-West Ward			261		295

Table B-2.4 provides an order-of-magnitude estimate of the present solid waste generation in K-West Ward.

Table B-2.4: Estimated solid waste generation in K-West Ward

Population	Solid waste generation	Solid waste density	Total solid waste generation	
5,80,000	0.40 kg/cap.d [1]	375 kg/m^3 [2]	230 tons/day	620 m^3/day

Notes
1) Assumed value including commercial waste, street sweeping, drain cleaning and institutional waste
2) Based on results of Group C (see Part C.)

Using the values obtained in Table B-2.4 the required capacity of community storage facilities is estimated in Table B-2.5.

Table B-2.5: Solid waste storage capacity in K-West Ward

Amount of solid waste collected at present	Estimated solid waste generation	Present collection rate	Required storage capacity for [4]	
			present collection	total generation
170 tons/day [1]	230 tons/day [2]	74% [3]	600 m^3/day [5]	815 m^3/day [6]

Notes
[1] Based on information obtained in the SWMD [2] See Table B-2.3 above [3] 170 / 230 = 0,74
[4] Refuse density 375 kg/cum (see Section C-...), provision of 33% excess storage capacity.
[5] 170 tons per day / 0,375 kg per cum x 1,33 = about 600 cum/day
[6] 230 tons per day / 0,375 kg per cum x 1,33 = about 820 cum/day

The table indicates that about 75 % of the solid waste generated in K-West Ward is collected by the present SWM system. Recycling activities reduce the amount of waste and therefore the actual collection rate may be slightly higher. Considering that there are no services provided to most of the private slum areas and that drains and open plots are used for refuse disposal to some extent a collection rate of about 75 % seems to be realistic.

Although the calculations carried out in the tables above cannot be regarded as precise because they are based on a approximate data, they show clearly that the present storage

capacity of community facilities in Ward K-West is totally insufficient. The estimated shortfall in storage capacity in K-West Ward is shown in table B-2.6.

Table B-2.6: Estimated storage deficiency in K-West Ward

Existing storage capacity	Estimated storage requirements for present collection rate	total generation rate
295 m^3/day (36%)	600 m^3/day (74%)	820 m^3/day (100%)

SUGGESTION: Table B-2.6 indicates that the present capacity of community storage facilities is only sufficient for storage of about 36% of the total amount of refuse generated in K-West Ward. It is therefore suggested that a strategy be developed for increasing the storage capaclty until sufficient capacity is available to cater for the present amount of waste collected by the SWMD. Storage deficiencies should be determined in each of the SWM districts of K-West Ward and priority areas identified.

The provision of adequate storage capacity is considered essential to the improvement of the cleanliness in K-West Ward and it is a necessary pre-requisite to the implementation of legislation regarding litter control.

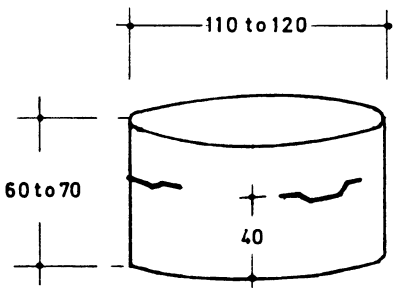
Considering that nearly twice the existing capacity is required this problem should become a priority measure for the improvement of refuse collection improvements. Regular monitoring of community storage facilities including their filling rate is required, and crude dumping areas (including drains and canals) need to be identified before a strategy for the elimination of crude dumping of refuse can be developed. The Junior Overseers may be the best people to collect the necessary data. This will further require major support by the Central Office including the allocation of funds and suitable strategies regarding the type of storage facilities and collection vehicles (see (ii) below).

(i) Types of community storage facilities

The five different types of community storage facilities in Ward K-West are shown in figures B-2.10 to B-2.13.

About 203 out of 282 storage containers are made from large diameter steel pipes as shown in figure B-2.10. The bins are primarily provided along secondary roads and in residential colonies including slum areas.

Figure B-2.10: Refuse bins made from steel pipe sections

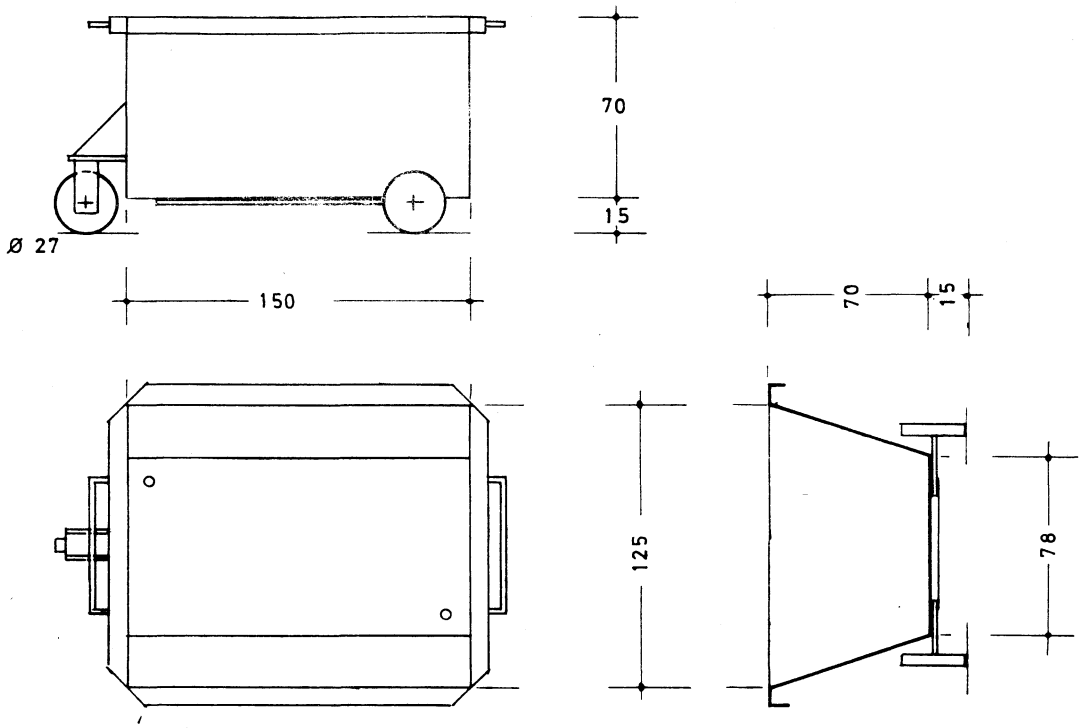


This bins are made from spare or used pipe sections of the water supply network in Bombay. The dimensions vary slightly, providing a capacity between about 0.6 and 0.8 m^3.
The bins are painted yellow and equipped with three handles, made from metal bars, as shown in the figure. Since the bins have no floors or bases, emptying involves tipping the bins over and manual loading into open trucks (usually contractors' vehicles).

Advantages:	Disadvantages:
Very cheap. Waste is confined by the bin (avoidance of littering). Suitable capacity for medium density residential areas. No special purpose vehicles required for emptying (can be used in conjunction with contractors' vehicles). Convenient height for emptying household containers and bins from handcarts. Little maintenance and repair is required. Durable (life span more than 5 years).	Difficult to handle (weight about 150 kg, a crew of at least four loaders is required to tip the bin for loading). Loading is labour intensive and very time consuming (inefficient use of trucks). Unhygienic conditions for loaders. Fly maggots burrow into soil through open bottom and develop in the soil. Littering during loading (so that cleanliness of locations is difficult to maintain).

Figure B-2.11 shows refuse containers which are used in conjunction with compactor trucks (also called compactor trolleys). These containers are located along the main roads and in high and multi-storey housing areas.

Figure B-2.11: Standard refuse containers (trolleys)

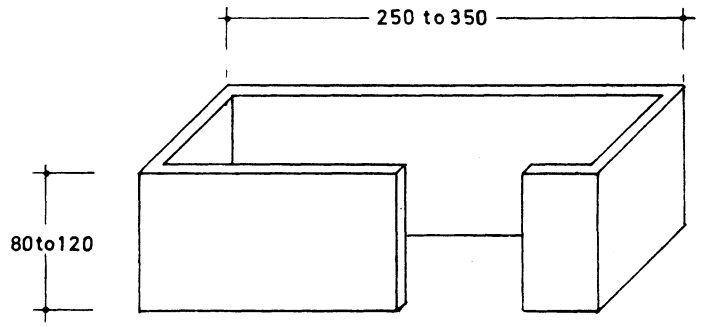


The trolley type containers provide a storage capacity of 1.0 m^3. Lifting and emptying these standardised containers requires special purpose vehicles like rear loading compactor trucks, which are equipped with a hydraulic lifting devices.

Advantages:	Disadvantages:
Rapid loading (efficient use of trucks). No manual handling of waste, therefore minimum health hazards for loaders. Loading less labour intensive (about three loaders are able to handle the containers). Direct loading of containers avoids littering. Less need of cleaning of container locations. Suitable capacity for medium density residential areas. Convenient height for emptying household facilities and bins from handcarts.	Only possible in conjunction with special purpose vehicles. Containers should be located on paved areas. Present system of private contracting is not suitable for using this type of facility. Relatively costly (compared with pipe bins). Regular maintenance is required. Life span may be less than five years.

Although they have mostly been replaced by pipe bins and trolleys, there is a small number of permanent structures used for community storage of refuse in slum areas and markets, known as refuse sheds and masonry enclosures. Refuse sheds consist of an masonry building including a simple roof (see figure B-6.3 below). A typical masonry enclosure is shown in figure B-2.12.

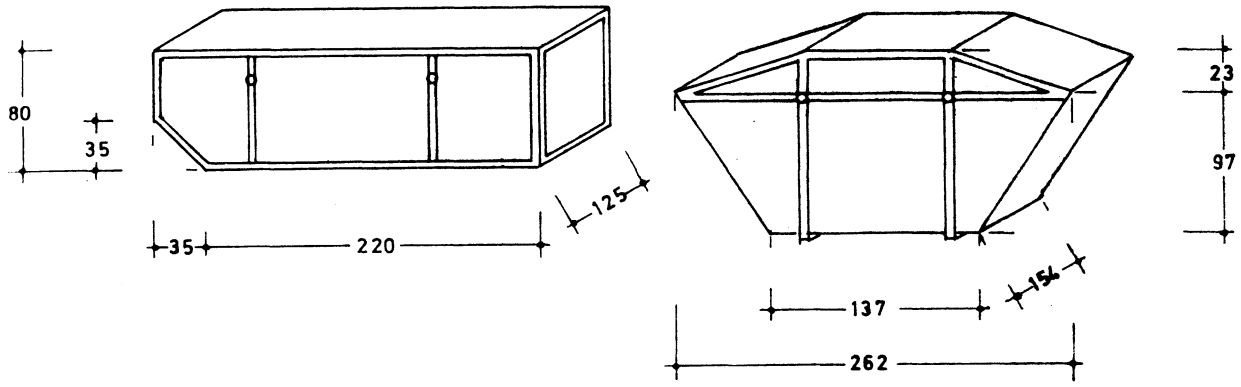
Figure B-2.12: Masonry enclosure (masonry bin)



Advantages:	Disadvantages:
Very cheap. Waste is partially confined to the enclosure. No special-purpose vehicles required for emptying (can be used in conjunction with contractors' vehicles). Little maintenance and repair is required. Durable - life span more than 5 years.	Loading from them is very difficult and extremely unhygienic. Ineffective litter control. Loading is labour intensive and very time consuming ⇒ inefficient use of trucks. Fly and odour nuisance due to large surface area. Cleanliness of surrounding areas virtually impossible, therefore unhygienic and inconvenient for users.

In addition to the facilities described above figure B-2.13 shows skip containers which are commonly used in the city centre of Bombay.

Figure B-2.13: Skip type containers



The larger skips with a capacity of about 3.7 m^3 are used by the MCGB in conjunction with skip trucks (dumper placers). Refuse collected by these vehicles is transferred to large capacity bulk transport vehicles at a solid waste transfer station.
A smaller skip with a capacity of about 2.5 m^3 has been observed at the landfill site and was used by a private deliverer in conjunction with a small TATA truck (type 407, GVW 5.3 tons).

Advantages:	**Disadvantages:**
Very rapid loading. No manual handling of waste, therefore minimum health hazards for loaders. Operation without loaders is possible, but one loader may be useful for connecting the lifting chains to the containers. Direct loading of containers avoids littering. Little cleaning of container locations is required. Suitable capacity for high density residential areas.	Only possible in conjunction with special purpose vehicles and probably a solid waste transfer station (for bulk transport). Present system of private contracting does not allow for using this type of containers. Lower costs than compactor trolleys. Some maintenance required. Life span may be about five years. Depending on the design the height for emptying household containers may cause problems, in particular for children.

SUGGESTIONS

- In an effort to achieve more hygienic conditions the present strategy of phasing out masonry bins and refuse sheds should be continued.

- In addition the present emptying frequency of once daily (seven days per week) is considered most appropriate because it allows costs for storage facilities to be minimised. Further investigations are required to evaluate whether introducing an emptying frequency of twice daily would be appropriate in high density housing areas. Considering the comparison of different storage facilities set out above it is thought desirable to gradually replace pipe bins by trolley type containers (in medium density areas) and probably skip type containers (in high density areas including slums). This strategy would:
  - avoid manual loading of refuse (a more healthy working environment for loaders);
  - reduce the labour costs for loading considerably;
  - utilise trucks more effectively;
  - achieve litter control and cleanliness of container locations;
  - introduce rapid unloading at the disposal site.

However, the implementation of this strategy is very difficult because the vehicles of the private contractors are unsuitable for handling containerised refuse collection systems. Measures to support the use of special purpose vehicles by the private sector have been discussed in Section A-4. They include a modified bidding procedure for contracts by giving preference to closed vehicles with mechanical container handling and unloading arrangements. This may be achieved by extending the contract period from two years to about five years and probably allowing an extension of contracts for a further five years under certain conditions.

- As a means of increasing the storage capacity to the requirements as set out in table B-2.6 above, it is suggested that additional pipe bins should be provided until the private sector is able to offer special-purpose vehicles and containerised systems.

Additional trolley type containers and probably skip systems may be introduced by the public sector when new vehicles become available. However, as already discussed in Section A-4, it is considered far more economic to increase the involvement of the private sector in refuse collection and transport. Therefore the strategy should aim at increasing the involvement of private contractors rather than providing additional vehicles operated by the public sector.

B-3 OPERATIONS IN JOGESHWARI SWM-DISTRICT

The location of Jogeshwari SWM district is shown in figure B-2.1 above. There are different residential colonies in Jogeshwari including all income groups (high, middle and low), high rise buildings and slums. It is further shown in figure B-2.1 that this district has a muster chowki which is only responsible for organising conservancy services in Jogeshwari SWM district (see section B-2.1).

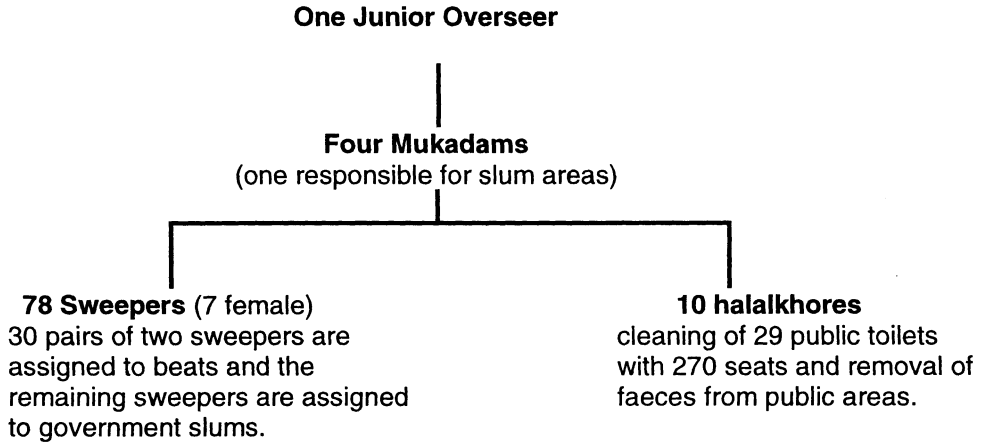
B-3.1 ORGANISATION, MANPOWER AND SUPERVISION

The organisation and manpower for carrying out conservancy services in Jogeshwari SWM District are set out in section (i). This is followed by a description of existing record keeping systems in (ii). Observations regarding the organisation of daily work as well as the supervision of conservancy staff at district level are outlined in section (iii).

(i) Organisation and manpower in Jogeshwari district

The organisational chart and manpower in the Jogeshwari SWM district is shown in figure B-3.1.

Figure B-3.1: Organisation Chart of the Jogeshwari Muster Chowki



It is shown in the chart that there are no drain cleaners assigned to this muster chowki. However, the JO explained that street sweepers carry out some drain cleaning activities in small drains (provided that the drains are dry).

Because the services are carried out 7 days per week, additional labour is required to allow one day off per labourer each week. A very clever system is employed by the SWMD to allow for the weekly day off for permanent employees. About 15 workers turn up at the morning attendance and are employed according to the particular daily requirements on a daily wage basis. For example on 1 December 1992 the following situation was observed:

> Out of 88 permanent employees 68 were present in the morning - 15 employees had their weekly day off and 5 were absent for unknown reasons. To cope with the shortage 4 additional workers were employed on a daily wage basis.

COMMENT: The organisation of conservancy services seems clearly defined at the different levels and so is considered satisfactory. In particular the arrangements regarding the employment of labour on a daily wage basis seems very suitable because it allows for flexibility without employment of permanent labour.

(ii) Records

A muster roll on daily attendance is checked by the JO in the morning and at the end of the working day. The following records are kept by the JO:

- Date, name of employee, attendance, reason for non attendance (i.e. regular weekly off, annual leave, casual leave).
- Names of workers employed on daily wage basis including names of permanent employees replaced by these workers.

A second record book is kept in the muster chowki regarding beats, public toilets, community bins and assignment of labour, i.e.:

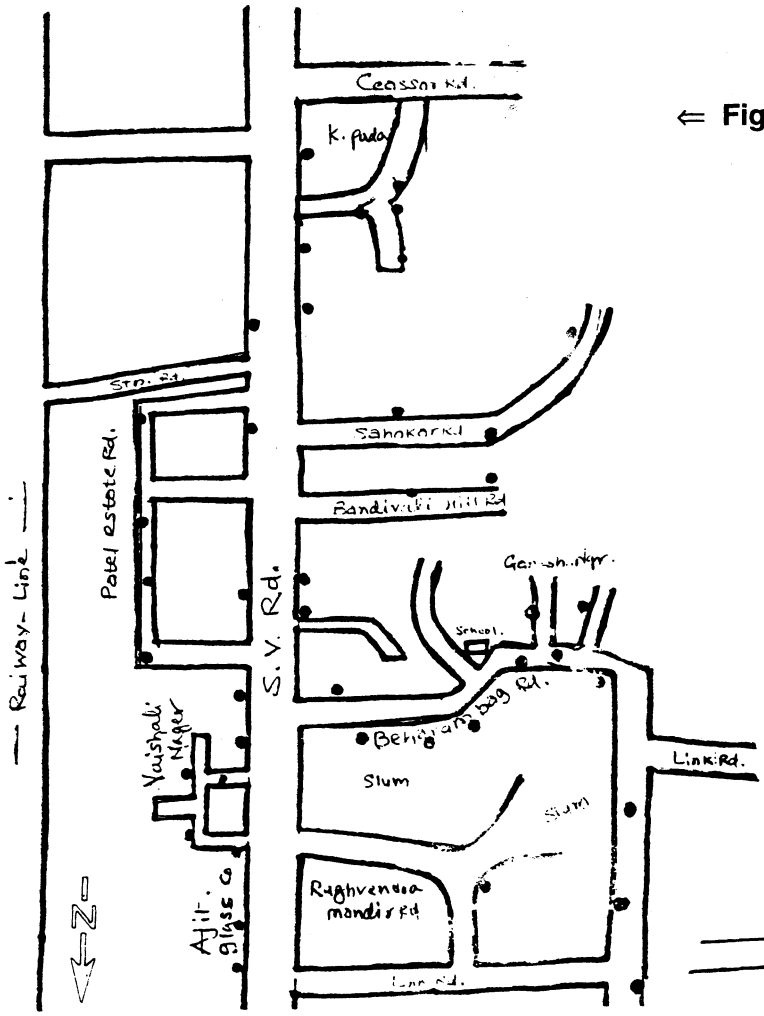
- Areas of beats are defined by mentioning the streets to be swept in each particular beat (total 30 beats).
- Names of the two sweepers assigned to each beat.
- Locations of community bins are described, i.e. name of street, junction or particular buildings (total 53 community bins).
- Location and name of public toilets (total 29 public toilets, 270 seats).
- Names of halalkhores assigned to particular toilets.

Although the records kept in the muster chowki have not been analysed fully, they appear to be complete and regularly updated by the JO.

In addition to the records kept at the muster chowki, two different sets of maps were provided by the SWM Office / K-West Ward. One type of map indicates community bin locations in each particular SWM district, and the other type shows the beats and assignment of sweepers in each district. A complete set of these maps, designed in 1990, was available in the SWM Office. Figure B-3.2 shows the sheet regarding bin locations in Jogeshwari SWM district.

However, this map was not available in the Jogeshwari muster chowki. It was also observed that the JO had considerable problems in reading the map and no updating had been carried out since 1990 (only 43 out of the 53 community bins had been marked on it). Although the map is based on a rough sketch it appeared suitable for showing the locations of the bins. More detailed observations in section B-3.3-(i) show that the locations of the storage facilities marked on the map seem to be mainly correct and that it is possible to identify the locations in the area, using the map.

A second map of Jogeshwari SWM district indicates the location of beats as well as the assignment of sweepers, and is as shown in figure B-3.3.



⇐ Figure B-3.2: Locations of community bins in Jogeshwari

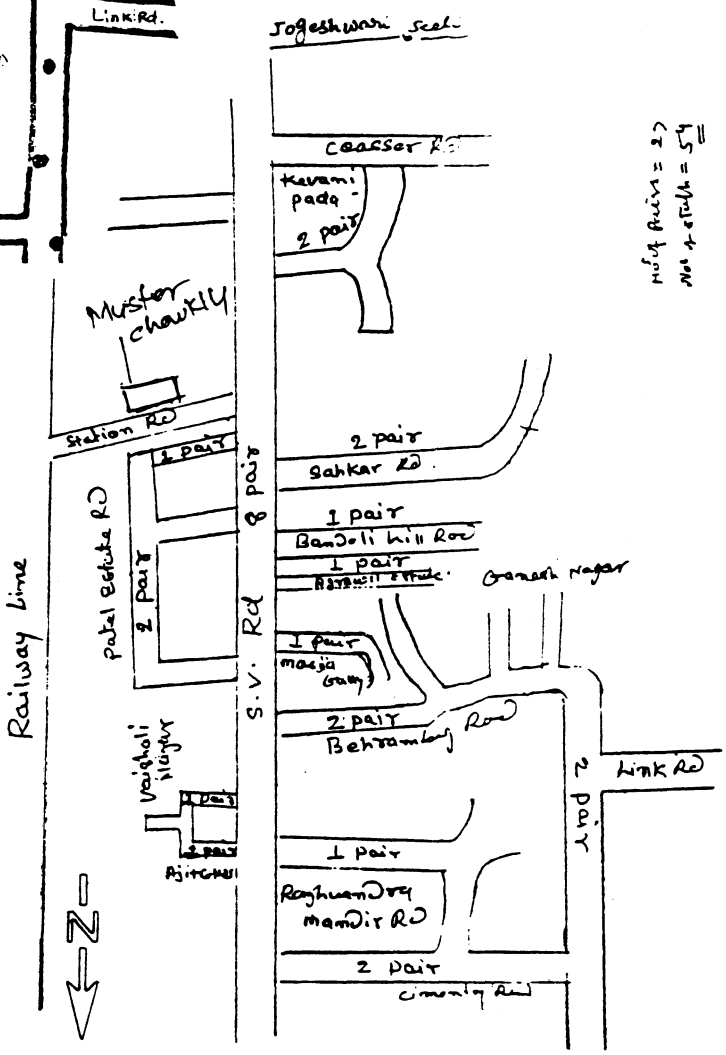


Figure B-3.3: ⇒ Beats and assignment of sweepers in Jogeshwari

The names of pairs of sweepers were written on the reverse of this map. Again, the map was not available in the muster chowki and not up to date (27 beats out of 30 were indicated, as were only 54 sweepers instead of 60).

SUGGESTION: The existing system of record keeping in Jogeshwari muster chowki is impressive, up to date, well designed and well functioning. However, it may be more appropriate to use maps for indicating beats, bin locations, public toilets and the assignment of labour. Although this system is already used by the SWM Office there seems to be a lack of co-operation between the muster chowkies and the SWM Office.
Based on these observations, it is considered desirable to introduce a single system, using maps rather than records, and to assign the updating of this map to the JO's. However, this seems difficult because JO's may have problems working with maps because they find them difficult to understand.
It is therefore suggested that junior overseers should be trained to interpret and use maps before the duties of updating the maps are assigned to these personnel.

(iii) Organisation of daily work and supervision

The organisation of the day to day street sweeping activities are set out below:

Attendance/assignment of labour	6.30 to 6.45 am
Walking to beats, toilets etc.	6.45 to 7.00 am (7.15 for very distant beats)
Working period	7.00/7.30 to 10.30 am
Tea break	10.30 to 11.00 am
Working period	11.00 to 1.00 pm (12.45 for very distant beats)
Walking to muster chowki	1.00/12.45 to 1.15 pm
Attendance at muster chowki	1.15 to 1.30 pm

The timetable above shows that the working period on the job is between 5 and 5½ hours daily (see also section B-2.1). However, observations in Jogeshwari indicate that the actual working time on the job ends with the tea break at about 10.30 am. During a visit to six different beats between 11.30 and 11.45 am not a single sweeper was observed on duty. More than 15 workers were been observed at the muster chowki at about 12.30. These observations indicate that the actual working time on the job is only between 3 and 3½ hours daily.

Although the duties of mukadams include supervision of their crews by carrying out two inspection rounds daily this seems to have little effect on the actual work carried out by labourers after the tea break.
Reasons may include that the JO's cannot punish the workers directly. The normal procedure involves writing a note regarding complaints to the supervisor. However, it has been reported that measures for punishment are very difficult to enforce because of the Labour Union's militancy and politicisation of strikes.

SUGGESTION: As already mentioned in section A-3.3, suitable measures to improve the supervision of labour and to increase the effective working period should be identified and enforced. This could include possibilities for JO's themselves to administer penalties to labour, such as deductions from salaries and rotation within the ward. It is considered totally unacceptable that employees, who obtain a comparatively good salary, cannot be forced to work during normal working hours. Measures aimed at increasing the output of the labour force are outlined in section B-3.5 below. In addition privatisation of conservancy services may prove a suitable way of reducing the labour costs involved in this sector.

B-3.2 PROVISION OF IMPLEMENTS TO CONSERVANCY STAFF

The type of equipment used by conservancy staff has already been discussed in section B-2.4, and aspects regarding protective clothing and uniforms as well as the need of regular medical checks have been dealt with in section B-2.4 above.

The Jogeshwari muster chowki consists of a well constructed building which is located at one of the main road junctions in Jogeshwari (see figure B-3.2). The dimensions of the building are about eight metres by three metres, divided into an office and a store room, both of similar size. Chairs and a table are provided, as well as water supply and electricity, including a fan. However, there is no telephone in the JO office. The store room is used for keeping a stock of about 40 baskets, cane for repair of brooms and some bags of disinfectant and insecticide.

Regarding handcarts, the following situation was observed:

AVAILABILITY OF HANDCARTS		HANDCART REQUIREMENTS		SHORTAGE OF HANDCARTS
total number	in working condition	for sweepers	for halalkhores	
20	8	30	5	15 plus 12 awaiting repair

According to the junior overseer, repair of handcarts is carried out by the central workshop. Although requests for repair had been addressed more than two months previously, nine of the broken carts were still at the chowki and there was no sign of action being taken to repair them. Because of the lack of handcarts, sweepers were using single cane baskets, which they pulled along the ground using a rope.

SUGGESTIONS

- The muster chowki is well designed, properly equipped and centrally located. However, to allow for better communication between the central, ward and district levels, it would be desirable to provide a telephone to the chowki.

- Regarding handcarts there seemed to be a total lack of co-ordination and support by the SWMD. Despite the general shortage of handcarts the arrangements for repair seemed to be totally inadequate. Instead of using the central municipal workshop it may be far more suitable to employ local workshops for maintenance and repair of simple equipment. It is therefore suggested that the AHS should be provided with sufficient funds for minor repairs of handcarts and containers as well as for petty cash purchases and minor maintenance.

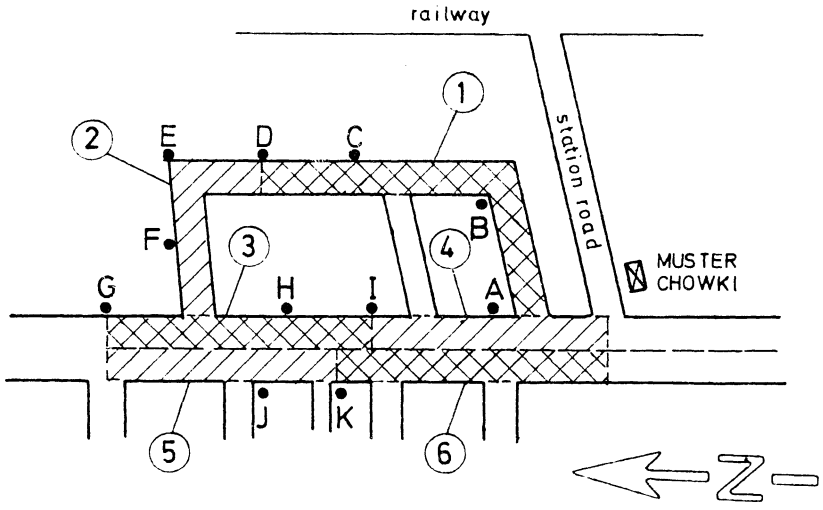
- For more difficult handcart repairs and for mending storage containers it may be most appropriate to introduce mobile repair and maintenance crews, based at the central workshops. Another option could be the assignment of one mechanic, probably assisted by one helper, to each of the two supervisors for repair of equipment in the SWM districts.

- In an effort to provide sufficient handcarts to the conservancy staff it is suggested that the situation in all SWM districts should be evaluated as soon as possible. The handcart deficiency should be made good immediately, including the provision of sufficient standby carts (say 10 %) to allow for repair without causing a shortage of carts in the districts. This should include replacement of very old and broken carts according to the strategy suggested in section B-2.4 (ii) above and include the provision of adequate baskets.

B-3.3 WORK EFFICIENCY STUDIES

The area chosen for carrying out work efficiency studies of sweepers is shown in figure B-3.4.

Figure B-3.4: Study area for work efficiency studies



As shown in the figure, the area covers six beats, each assigned to one pair of sweepers. The beats are marked 1 to 6 and the eleven community bin locations in the area are marked A to K.

The division of beats and the assignment of sweepers in the study area is discussed in (i) and followed by more detailed observations regarding performance of sweepers in (ii). Section (iii) deals with community storage facilities in the study area and the impacts of rag pickers on littering are outlined in (iv).

(i) Division of beats and assignment of sweepers

It is shown in figure B-3.4 that in small roads (width about 12 metres) one pair of sweepers is responsible for sweeping both sides of the road (beats 1 and 2), whereas along the main road (width about 24 metres) one pair of sweepers is assigned to each side of the road (beats 3 to 6). Table B-3.2 provides a summary of the main features regarding street sweeping in the study area.

Table B-3.2: Assignment of sweepers in the study area

	---	---secondary road----------					------main road---------				------main road --------				
BIN LOCATION	A	B	C	D	E	F	G	H	I	A	(G)	J	K	(A)
DISTANCE [m]	150	150	250	150	210	250	180	180	150	150	250	80	180	150
PAIR NUMBER	.....	.....1.....			.....	.....2.....		.....		.....	3.....	.....	.....4.....	.....
	5.....	.....	6.....											
METRES/PAIR		550			610			360		300		330		330
BINS/PAIR		4			4			3		2		2		1

Based on the data shown in table B-3.2 some general comments are set out below:

- The average length of beats along main roads is 330 metres, ranging between 300 and 360 metres (sweeping is carried out by one crew along each side of these roads). In secondary roads about 580 metres are assigned to one pair of sweepers (responsible for sweeping along both sides of the road). According to information obtained from the CE/SWM, the average area of roads and lanes within one beat is between 3,000 and 5,000 square metres in busy areas (e.g. along main roads) and 5,000 to 10,000 square meters in quiet areas (e.g. suburbs).

- In the study area about 4,000 square metres (330 x 12) are assigned to the sweepers along the main roads and 7,000 square metres (580 x 12) to sweepers along secondary roads; therefore the division of beats in Jogeshwari seems to be very well arranged.
- Regarding the distribution of community bins for sweepers, the average distance between the storage facilities is about 180 metres, ranging between 80 and 250 metres.
- Along the secondary road each pair of sweepers was using 4 bins for disposal of street sweepings whereas along the main road between 1 and 3 bins are available per pair of sweepers.
- In case of pairs 5 and 6, the sweepers were forced to cross the busy main road to reach the containers G and A.
- The map of community storage locations which was provided by the SWMD proved almost correct. Only the bin location F is missing and some of the locations are marked on the wrong side of the road (namely B and D).

The division of beats in Jogeshwari seems to be very well arranged. The work load is equally distributed between the sweeping crews. Some suggestions are discussed below and others in section (ii), *performance of sweepers*, which follows.

SUGGESTIONS

- Due to the small amount of street sweepings in secondary roads it is suggested to reduce the frequency of sweeping in some of the secondary roads to every other day. Further investigations are suggested to review the frequency of sweeping in secondary roads.

- Although a more equal spacing between storage facilities would be desirable it is suggested to provide the containers according to the refuse generation at central locations, to allow for some variation between the facilities (see ii below).

- In order to avoid accidents the sweepers should not be required to cross main roads (as do pair 5 and 6 in table B-3.2). Therefore additional containers should be provided on the opposite side of the road in the area of the containers A and G (see figure B-3.4).

(ii) Performance of sweepers

The following implements were being used by the six pairs of sweepers in the study area:

Table B-3.3 Equipment used by the sweepers who were observed

Team	Method of transport	Other equipment
Pair 1	No handcart. 60 litre basket with rope	One broom, wooden boards
Pair 2	Only one sweeper on duty. Type A handcart in good condition. Cart was not used (locked at lighting post, key of the lock was kept by the other sweeper who did not report for work that day).	One broom, wooden boards
Pair 3	No handcart. 60 litre basket with rope	One broom, wooden boards
Pair 4	No handcart. 70 litre basket, carried by loader.	One broom, wooden boards
Pair 5	Wheel barrow type cart in good condition	One broom, wooden boards
Pair 6	Type B handcart in good condition, two baskets (capacity about 75 and 60 litres	One broom, wooden boards

Considering the shortage of handcarts observed in Jogeshwari district it is not surprising that only three out of the six crews shown in the table were equipped with handcarts. It is further shown that only one broom is provided per crew. Therefore one of the sweepers is responsible for sweeping whereas the other is responsible for loading the street sweepings and transporting them to the nearest community container.

Estimates of the performances of three pairs of sweepers, based on observations and interviews with the crews, are presented in table B-3.4.

Table B-3.4: Performance of sweepers

	Basket/handcart capacity [litres]	Estimated density [kg/l]	Weight of filled basket/handcart [kg]	Loads per time interval [no.]	Time interval [min.]	Performance of the pairs [kg/h]
Pair 1	about 60	0.35	21	2	45	56
Pair 5	about 175	0.35	61	3	180	61
Pair 6	about 135	0.35	47	4	195	58
Average performance of sweepers about 58 kg/hour per pair, equal to about 200 kg/day [1]						

Note [1] Considering an effective working time of 3.5 hours per day, see Section B-3.1-iii.

Although observations on a larger scale would be necessary to obtain more reliable data the values shown in the table above may provide an idea about the present distribution of work within the pair system.

It is shown that the performance of the three pairs does not vary considerably. This may be surprising because pair 1 was not equipped with a handcart and pair 5 was using a wheel barrow type cart which involves double handling. However, it has been observed that only about 2 minutes are required to transfer the wheel barrow load into a trolley container (the load is tipped to the ground beside the trolley and loaded manually).

The results are very uniform because the work load within the pair system is very imbalanced. As will be shown in the following section, the person in charge of loading and transporting the sweepings has plenty of time and therefore the impact of poor transportation equipment on the performance of the pairs is negligible.

It has been observed that the pairs manage to sweep their beats within 3 to 3½ hours. The amount of sweeping per beat is estimated as:

In main roads: about 200 kg/day from 4,000 m^2 (one road side, length of the kerb about 330 metres).
In secondary roads: about 200 kg/day per 7,000 m^2 (both sides of the road, length of road 580 metres, kerb length about 2 x 580 metres = 1060 metres).

The activities of Pair 1 have been observed in more detail to assess the effective working time of each person within the pair system. Results of the work efficiency study are shown in Table B-3.5.

Table B-3.5: Effective working time of sweepers

Time scale in minutes	0	20	40	60
Activities of SWEEPER	S S S S S S S S	S S S S S S S R	R S S S S S S S	S S S S
Activities of LOADER	----------L	T----------	L--T----------L	T------

Legend: S (sweeping), R (repair of broom), L (loading), - (non productive), T (transport)

It is shown in the table that the person who is sweeping may be productive for up to 60 minutes per hour whereas the person loading and pulling the basket to the container works for only about 17 minutes per hour. Therefore the use of well-designed handcarts would only reduce the working time of the loading and transport person to less than 17 minutes per hour. Hence, without changing the present sweeping system any investment in handcarts and baskets would be a total waste of funds.

Considering that the actual working time on the job is less than 3½ hours per day, the person who loads and transports the street sweepings receives a full salary for working less than one hour per day.

It has been reported *off the record* that it is not uncommon to find a couple who share the work. Only one of the two is present to do the job and the other person only reports twice daily for attendance at the muster chowki.

There are two main shortcomings observed regarding the performance of sweepers:
- Although the official working time on the job is between 5 and 5½ hours per day, the actual time spent on the job is only 3 to 3½ hours.
- The workload within the pairs of sweepers is very unevenly distributed. The person responsible for loading and transport remains idle for almost 3/4 of his working time.

SUGGESTION: two different possibilities for improving the present situation:
- Improvements of the pair system such that both persons of the pair are equipped with a broom for sweeping. This would increase the effective working time of the crew considerably.
- The second option is to assign only one sweeper to each beat (an arrangement that is common in other municipalities in India).

Table B-3.6 further indicates the potential performance of sweepers by adjusting the sweeping period to the official working hours.

Table B-3.6: Comparison of different sweeping arrangements

	Present pair system		Improved pair system		One sweeper per beat	
Period working [hours per day]	3 to 3½	5 to 5½	3 to 3½	5 to 5½	3 to 3½	5 to 5½
Performance along main roads [m^2]	4 000 (1)	6 500 (2)	5 700 (3)	9 200 (2)	2 850 (4)	4 600 (2)
Performance along secondary roads [m^2]	7 000 (1)	11 300 (2)	10 000 (3)	16 100 (2)	5 000 (4)	8 050 (2)

Notes
1) According to (i) above.
2) Ratio 5.25 / 3.25 = 1.61 used here.
3) Each person spends 17 min/hour for loading and transport and 43 min/hour for sweeping.
   Effective sweeping period per pair is 2 x 43 = 86 min instead of 60 min at present.
   This allows to increase the performance of the pair by 83/60 = 1.43.
4) The person spends 17 min/hour for loading and transport and 43 min/hour for sweeping.
   One sweeper would achieve 43/60 = 72 % of the performance of the present pair system.

Both options shown in the table would allow for improving the efficiency of sweepers by at least 42 %. The provision of adequate handcarts [see section B-2.4-(ii)] would allow a further increase in the performance by reducing the transport and transfer time.

Although there were no small drains in the study area, it may be most suitable to assign cleaning of the small drains to sweepers, i.e. drains in a particular beat should be cleaned by sweepers in charge of the area [see section B-2.2 (ii)].

(iii) Locations and filling rates of community bins

Community containers in the study area (see figure B-3.4) were closely observed during the studies in Jogeshwari. The capacity of refuse in the containers was recorded (as a percentage of the total container capacity) as well as the condition of the facilities and cleanliness of the locations. The results are summarised in table B-3.7.

Table B-3.7: Monitoring of community storage facilities

Location	Type of container	Capacity m^3	Condition	Percent full (8am -9am)	Frequency of emptying	Percent full (noon - 1pm)	Cleanliness of location
A	trolley	1.00	wheel broken	50	twice/day	>100	good, paved
B	pipe bin	0.70	good	75	once/day	>100	bad, unpaved
C	pipe bin	0.64	good	30	once/day	100	bad, unpaved
D	pipe bin	0.62	bad	30	once/day	>100	bad, unpaved
Comment: Slum dwellers dump refuse in an open drain close to bin D							
E	pipe bin	1.50	very bad (1)	10	once/day	30	bad/unpaved
F	pipe bin	0.68	good	20	once/day	50	good, paved
Comment: Private collectors dump refuse over a wide area on adjacent private property							
G	trolley	1.00	good	75	twice/day	90	good, paved
H	trolley	1.00	good	75	twice/day	>100	good, paved
I	trolley	1.00	good	60	twice/day	100	good, paved
J	trolley	1.00	good	20 (2)	twice/day	60	good, paved
K	trolley	1.00	wheel missing	20 (2)	twice/day	70	good, paved

Note
1) Very old steel bin, diameter 1.5 metres, height 0.6 metres.
2) These trolleys had already been emptied that the morning.

Some general comments on storage, based on the observations summarised in table B-3.7, are set out below:

- Trolley type containers are placed along the main road and allow for proper cleanliness of the locations. (It is duty of sweepers to keep these areas clean.) An emptying frequency of twice daily seems to be of help in keeping these areas clean. Rag pickers were observed at all trolley locations. They did not cause severe problems regarding cleanliness around the trolley containers.
- Steel pipe bins are located along secondary roads; the cleanliness of the surroundings of the bins was unsatisfactory in most cases. Reasons include that the locations were not paved and therefore very difficult for the sweepers to clean and inconvenient for the public.
- Monitoring of the filling rate of the community bins shows that six out of eleven facilities were already full or overflowing by lunch time. This indicates a general lack of storage capacity, as discussed in section B-2.5 (i).
- There seems to be a maintenance problem regarding compactor trolleys. Two out of five trolleys needed repair (broken or missing wheels). In addition cleaning and repainting of containers was not carried out regularly.
- There were a number of crude dumping areas used by the public in the immediate vicinity of storage facilities.

SUGGESTIONS

- The presence or absence of a paved area around community storage facilities pavement seems very to have a big influence on the cleanliness of the sites. It is therefore suggested that all community storage facilities should be paved.

- To avoid overflowing containers and bins, a regular monitoring of filling rates is suggested. The mukadams and the JO's should become responsible for carrying out this monitoring. The results should be collected by the supervisors and passed on to the Central Office in order to decide on the provision of additional storage facilities according to the requirements identified. This would probably allow a reduction in the distance between storage facilities to less than 150 metres.

- An adequate system for organising the maintenance and repair of storage facilities seems to be required. Monitoring of the facilities regarding maintenance and repair could be carried out either by collection crews or by JO's of SWM districts. Since the vehicle crews are directly affected by missing wheels etc. it may be more suitable to

assign this duty to the mukadams of collection vehicles. A mobile repair and maintenance team may be most appropriate for carrying out maintenance and repair of trolley containers (and handcarts, see section B-3.2). It may be sufficient to base one mobile team at each central workshop.

- To prevent dumping of refuse in drains and open areas, additional storage should be provided at places where indiscriminate dumping is practised. This is particularly difficult in private residential areas because the SWMD is not responsible for cleaning on private property. However, adequate legislation and enforcement, coupled with co-operation between the SWMD and housing boards, may help to develop suitable arrangements.

- Public awareness campaigns are certainly required to reduce crude dumping of refuse. Section A 3.5 (ii) discusses this subject in more detail.

(iv) Littering by rag pickers

Recycling of saleable material is carried out at the community storage facilities by rag pickers and private collectors. Private sweepers tip the refuse bins into the containers and pick out anything of value, which is placed into the empty bin. It was observed that this procedure did not cause littering around the storage containers (provided that the facilities were not overfilled).

Scavenging by rag pickers involves far more extensive digging in the storage facilities. Some pickers place the materials on several heaps at the locality, whilst others remove parts of the contents to an area beside the facilities to allow scavenging in deeper layers within the trolley containers. Although refuse is sometimes replaced in the containers in this type of situation, it has been reported (and observed at other localities) that rag pickers are one of the main causes of littering around the community facilities.

SUGGESTIONS

- Littering by rag pickers and private refuse collectors is certainly more extensive if community containers are overfilled. Therefore the provision of adequate storage capacity is a pre-requisite for reducing littering at storage sites.

- Paved locations for community bins and trolleys may further help to reduce littering because they allow more convenient access, good conditions for sweeping and better working conditions for rag pickers.

- Another suggestion that might minimise the nuisance caused by rag pickers requires the provision of two storage containers at one location. Instead of depositing refuse outside the containers, rag pickers could transfer refuse from one container to the other as they look for items they can sell.

- Finally, some punitive measures are suggested to avoid littering by rag pickers. Possibilities could include the banning from scavenging in the district of those who cause most nuisance, or alternatively, the confiscation of material that they have collected.

B-4 INVESTIGATIONS IN SLUM AREAS

According to the SWMD, the total number of slum areas in K-West Ward is 93 (45 on private land, 35 on government land, 9 on municipal land and 4 on land belonging to housing boards). Records at the ward office show that 68 of these slum areas are declared slums (15 on government land, 7 on municipal land and 46 on private land).

Public sector conservancy services are only provided to declared government and municipal slums. Conservancy services for the remaining categories are either non-existent or

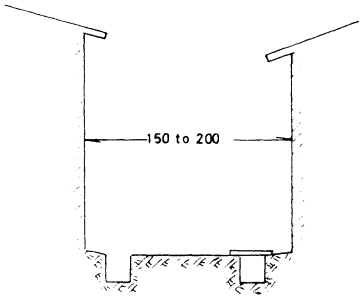
provided on a private contract basis; adjacent main roads are sometimes cleaned by the public sector. According to the WO, six of these slums are already served on a private contract basis within pilot projects. It was also mentioned that these projects had been very successful and that another eight private slum areas would be included in the year 1993.

Investigations have been carried out in three different slums, namely in the government slum Gilbert Hill (section B-4.1) and in two private slums - Bauder Ville (section B-4.2) and Behram Bagh (section B-4.3). Bauder Ville is on a hilly site whilst Behram Bagh is on flat land. The studies are based on field visits and on results of a household questionnaire survey which is discussed in section B-4.4.

B-4.1 GILBERT HILL SLUM

Gilbert Hill consists of about 8,000 buildings with around 48,000 inhabitants. The people live in single storey masonry buildings, and two-storey buildings with shops on the ground floor are common along main lanes. Access is via a few main roads with some paving, and along narrow sloping lanes with concrete surfacing. Open drains, located at one or both sides of the lanes, are used for sullage disposal and drainage, as shown in figure B-4.1.

Figure B-4.1: Typical lane in Gilbert Hill



Dwellings on government property are provided with municipal services by the SWMD. They include sweeping of lanes and roads, removal of refuse from the area, and cleaning of drains and public toilets.

Storage facilities for domestic refuse include 19 community bins (pipe section type) and 3 masonry enclosures. The municipal work force of 45 persons consists of 13 sweepers, 12 halalkhores, 18 drain cleaners and two mukadams. Services are provided 6 days per week (Sunday is a holiday).

Houses are usually without sanitary facilities; there are 25 public toilets with around 20 seats each.

(i) Public toilets

Observations in two public toilets indicated that cleaning was unsatisfactory and that some of the toilets were blocked. The residents complained that these latrines were not cleaned regularly by the municipal staff. Children were frequently observed defecating in front of the toilets and close to the community bins.

(ii) Primary collection and storage of refuse

As with the slum areas on public land it has been observed that refuse was being deposited into drains and that the existing storage facilities were overflowing. To estimate the storage deficiency in Gilbert Hill the storage needs are compared with the existing capacity of community bins in table B-4.1.

Table B-4.1: Refuse storage in Gilbert Hill

Existing storage capacity m^3 (1)	Estimated refuse generation		Estimated storage requirement m^3 (4)
	kg/day (2)	m^3 (3)	
23.3	16,800	42.0	about 56

Notes
1) 19 pipe sections, 0.7 m^3 each = 13,3 m^3. 2 masonry facilities, about 5.0 m^3 = 10,0 m^3
2) Assuming 48,000 people x 0.35 kg/cap.d (in low income communities) = 16,800 kg/day.
3) Assuming a density of about 400 kg/m^3 (in low income communities) = 16,800 / 400 = 42.0 m^3.
4) Considering daily emptying (7 days per week) and the provision of 33% excess storage capacity.

It is shown in table B-4.1 that the present capacity of the community bins allows for storage of less than 50% of the amount of refuse generated in Gilbert Hill. This may be one of the main reasons for the overflowing containers and crude dumping of refuse. This idea is reinforced by the responses to Questions 6 and 7.

(iii) Street sweeping and drain cleaning

According to the JO, sweeping of roads and lanes was being carried out on alternate days; the small drains were being cleaned once a week according to a fixed programme. It was also mentioned that the public sector did not cover the entire area and that some private sweepers were employed by the residents in some parts of Gilbert Hill.

As shown in figure B-4.1 the many of the lanes are concreted and open drains have been provided for drainage of the area. Although the concrete surface allows for convenient sweeping, it is very difficult to prevent the sweepings entering the drains. It was observed that a considerable amount of waste was accumulating in these drains and that blockage was common. This may be caused by residents who dump their waste in the drains or by waste not being properly contained in storage sites and subsequently carried to the drains. The drains are used for sullage disposal and so refuse in them becomes wet and difficult to remove. During dry weather peak flow in the drains occurs in the morning (water is supplied from 6 am to 10 am), causing flooding in areas with blocked drains.

It was also observed that refuse disposal to a large drain inside the area leads to considerable risk of severe flooding. Due to limited access cleaning is very labour intensive. These drains are occasionally cleaned by a private contractor. One of the cleaning crews was seen dumping drain cleanings behind a community bin and it appeared that this material was never removed.

B-4.2 BAUDER VILLE SLUM

Bauder Ville slum is located on private land in the north-east part of K-West Ward. About 9,000 people live in Bauder Ville, in 1,500 simple single storey buildings. The community is located on a small hill and access is provided via an asphalt road, ending at the boundary of the area. However, an unpaved road in good condition continues to the centre of the community on top of the hill.

Services provided by the MCGB include one public standpost, toilet facilities and a refuse bin. These facilities are grouped at the boundary of the community, along the main access road.

(i) Public toilets

The public latrine was dirty and rarely attended by municipal staff.

(ii) Primary collection and storage of refuse

The existing refuse bin is primarily used by the street sweepers responsible for cleaning the public roads in the vicinity of Bauder Ville. Domestic refuse from the community had been dumped at various locations on the slopes of the hill but never removed by a collection crew and so it had been washed downhill during the monsoon season. This created very unhygienic conditions in the community and also contributed to blocking of the drains further down the hill, and flooding.

(iii) Street sweeping and drain cleaning

According to information obtained locally, street sweeping in the community had been carried out by a private contractor. The contract had been terminated in September 1992 (two to three months before this study) and there were no services provided at the time of the survey. The residents had been satisfied with the service and they hoped that a new contract would be agreed with effect from January 1993.

The contract included the provision of four workers for daily street sweeping at a cost of Rs 535 per worker (to cover an area in which about 9,000 people were living).

There was an obvious need for drain cleaning services. It was observed that the drains along the main access road had not been cleaned for a long period and that refuse disposal to the drains caused flooding of public areas. Drain cleaning by the maintenance department seemed to be inadequate or non-existent in this area.

B-4.3 BEHRAM BAGH SLUM

Behram Bagh is located on private property in a relatively flat area. Based on information obtained locally there are about 10,000 dwelling units with a population of around 60,000. Housing consists of single storey masonry buildings, usually without direct access for vehicles. Small lanes, partially concreted, are connected to the few asphalt roads in the area.

Although the public sector is usually not involved in the provision of conservancy services in private slums, some services were being provided in this case. These included the provision of about 15 community bins (steel pipe sections) as well as sweeping of the asphalt roads inside the slum area by municipal sweepers; 8 sweepers had been deployed for this purpose with 4 handcarts. However, some of these bins were located on public ground at the boundary of Behram Bagh and the sweepers were also responsible for sweeping public roads around the areas.

As in Bauder Ville, some community members were asked for their opinions regarding conservancy services. However, due to time constraints, only nine questionnaires were completed, which is certainly insufficient for a valid assessment. Therefore only a few results are presented in this section and comments are primarily based on the observations carried out in the locality.

(i) Public toilets

As in Bauder Ville, maintenance and cleaning of public toilets is inadequate and was considered by five out of nine community members to be the most significant problem. This had been recognised by the local authorities and a new 'Sulabh System' toilet was under construction at the boundary of Behram Bagh.

(ii) Primary collection and storage of refuse

Applying the estimated refuse generation rate and density according to table B-4.1 above, the total waste generation in Behram Bagh was estimated to be about 21 tons per day, which is equivalent to about 53 m^3 per day. Hence, the present storage capacity of community bins of only about 10 m^3 is totally inadequate.

This was confirmed during the studies in the locality. Most of the people were using open spaces and marshy land in the vicinity of the housing areas for refuse disposal (including a large area which is used for silt and debris disposal by the SWMD).
When interviewed, some householders explained that they employed private sweepers for cleaning the lanes and collection of domestic waste. However, because of the lack of storage facilities, only a small proportion of refuse was being deposited into the community bins provided. It appeared that the bins were not emptied regularly and that waste remained for up to one week in the facilities.
According to the JO, the refuse which accumulated in areas which were accessible for vehicles was being removed three or four times yearly.

COMMENT: The provision of sufficient storage facilities and regular removal of refuse is considered the main shortcoming in Behram Bagh. Refuse collection could either remain within the responsibility of the public sector or be handed over to a private contractor, as was done in Bauder Ville.

SUGGESTIONS

- Further investigations are required to identify suitable locations for community facilities. Limited access to the area will probably lead to relatively long distances between the containers. Therefore larger capacity storage facilities like skips would be more appropriate than trolleys or pipe bins (see section B- 2.5-(ii)). However, since the public sector is usually not required to provide services to residential areas located on private property it may be more suitable to hand over the duties of providing storage facilities and refuse transport to the private sector. Pipe sections, probably arranged on paved areas in groups of two or three, would produce a considerable improvement in the present situation .

- In addition, publicity and awareness campaigns - including cleanup campaigns - are considered crucial in helping the residents to change their present dumping practices and use the facilities properly. (Only one out of the nine residents interviewed had ever been advised on cleanliness and public health issues). This would require support by the public sector including the WO and the SWMD (see section A-3.5).

(iii) Street sweeping and drain cleaning

The main cause of littering in Behram Bagh is the accumulation of refuse in virtually all larger open spaces in the community. Because the waste is not confined to containers, it is totally accessible to scavenging animals, children and wind, and therefore is soon scattered around the dumping areas. This could be reduced considerably by implementing the improvements suggested in the previous section. This would also reduce the need of sweeping and cleaning of roads and open spaces.

It has been observed that the people of Behram Bagh clean the lanes and small yards in front of their houses regularly.

SUGGESTIONS

- The present sweeping system along main roads is considered adequate and residents should be encouraged to continue sweeping the other areas.

- Although few problems have been observed regarding surface water drainage in the area, it is suggested that street sweepers should become responsible for drain cleaning along the main roads, whereas cleaning of drains in small lanes should remain the responsibility of residents.

- Drain cleaning, street sweeping and the provision and emptying of refuse storage facilities should be carried out by a single authority, either public or private.

B-4.4 RESULTS OF QUESTIONNAIRE SURVEYS AND RELATED SUGGESTIONS

In order to have first-hand information regarding the most neglected services in slum and other areas, and about the opinions, needs and aspirations of the residents, and to learn more about the current systems of sweeping and storage, a questionnaire comprising twenty questions was prepared for government and private slums. (Questionnaires were also prepared for other areas - single-storey houses, and multi-storey flats; the replies from these areas are discussed briefly in section B-5, and in Part D where they refer to resource recovery.) A survey of 43 houses in Gilbert Hill government slum, 40 houses in Bauder Ville private slum and 9 houses in Behram Bagh private slum was carried out with the help of enumerators from the All India Institute of Local Self Government. (Time did not permit a sufficiently large sample to be questioned in Behram Bagh so any results from that area have been mentioned in section B-4 3 and are not included here.)

The following problems were encountered in conducting the survey:
- At the time of survey - during working hours - the male members of the households some information could not be obtained.
- There were no lady enumerators; it would have been better if female enumerators had been available to talk with female residents.
- People complained that such surveys were often made but no action was ever taken to solve their problems.
- The enumerators had received no training in solid waste management and so were not much aware of the background of the subject. They were also not very familiar with the areas being surveyed.

These problems should be considered when planning future surveys.

Some of the questions that were asked and a summary of the replies are reproduced below, together with comments on the responses, and observations and suggestions that relate directly to the issues under consideration

Q-1: Please rank neglected services in your locality in order of importance.

GILBERT HILL	Water supply	Toilets	Flooding	Refuse	Roads	Electricity
First priority	2	22 [52%]	3	9	7	0
Second priority	6	8	16 [38%]	8	4	2
Third priority	1	10	10	19 [44%]	3	0

BAUDER VILLE	Water supply	Toilets	Flooding	Refuse	Roads	Electricity
First priority	5	27 [68%]	3	3	2	0
Second priority	10 [25%]	4	10 [25%]	8	6	2
Third priority	7	7	11 [26%]	8	4	3

The answers showed that residents consider toilets to be the most neglected service in their community.

In **Gilbert Hill** the next priorities were flooding and refuse collection. Although water was being supplied only between 6 am and 10 am, this was considered to be an acceptable service by most of the people and the improvement of roads was ranked higher than water supply. Finally, electricity was regarded as reliable and was not considered to be a problem. Flooding by blocked drains is commonly caused by uncollected refuse. Therefore improvements of the refuse collection system would help to avoid flooding to some extent.

In **Bauder Ville** the second priority was divided between water supply and flooding. Although refuse did not rank very high it should be considered that flooding by blocked drains is commonly caused by uncollected refuse. Hence, when considering flooding and refuse collection as a combined issue the ranking would become similar to water supply.

COMMENT: This document does not intend to analyse all the different services in more detail. The cleaning of public toilets, drain cleaning and refuse collection will be discussed in more detail below.

Q-2: Please think about the public toilet in your area and choose the most serious problem:

	Poorly maintained	Place very dirty	Place far away	Lack of water
Gilbert Hill	9 [21%]	29 [67%]	5 [12%]	0
Bauder Ville	13 [33%]	22 [55%]	3 [7%]	2 [5%]

The answers indicate that a clear majority of the people considered poor cleaning and maintenance of toilets to be the main reason for the unsatisfactory situation.

Question 3 was based on the observation that children in slum areas often defecate in front of public toilets.

Q-3: Why do you think many children do not use these toilets?

	Parents do not like these places	Difficult for children to use	Others
Gilbert Hill	8 [19%]	26 [60%]	9 (no opinion)
Bauder Ville	13 [32%]	25 [63%]	2 [5%]

The answers indicate that toilets are difficult to use for children. Another reason may be that parents do not show their children how to use the toilets properly (probably because they do not want them to go there). Children may feel very uncomfortable because the toilets are very dark. Others have mentioned that children do use the toilets.

Faeces around the toilets are removed by the halalkhores using wooden boards and a wheel barrow type cart. In the case observed, the worker did not use gloves and the cart was emptied on the ground behind a community bin. It seemed to be standard practice to dump drain cleanings and faeces at this locality. The material was not removed by municipal trucks and so was accumulating. There were many children playing and scavenging at this locality so this practice was certainly contributing to the spread of disease.

SUGGESTIONS

- Although the public sector provides cleaning and maintenance services for the toilets, they seemed to be not properly arranged. Possible improvement measures might include a scheduled cleaning service by halalkhores of the SWMD including strict supervision.

- However, observations in all slum areas visited during the studies suggested that this option is not very promising. It has been suggested that *private* agencies should be entrusted with construction, maintenance and cleaning of public toilets. Regarding existing public toilets, similar arrangements may be feasible. This could include selling off the structures to a private agency which would become responsible for maintenance, operation and revenue collection.

- Consideration should be given to fostering the involvement of the community in toilet cleaning and maintenance. It may be possible to encourage community leaders to take the responsibility and to arrange for cleaning and maintenance within the community. Charging a small fee from users of toilets may be appropriate rather than providing a cost-free service.

- However, further investigations are considered necessary regarding cleaning and maintenance of public toilets. Private agencies could be entrusted with construction, maintenance and cleaning of public toilets. In Delhi, for instance, this has been introduced successfully. The contract with the agency (Sulabh International) includes construction, maintenance and cleaning of toilets as well as the collection of user charges by a user card system. All male community members are issued with a card at Rs 10 per month for using the toilets whereas women and children use the toilets free of charge. It has been observed that one of these toilets is under construction at the boundary of Behram Bagh slum.

- The present practice of dumping human faeces beside community bins is by no means acceptable. Training and supervision of halalkhores is suggested to ensure that all material collected is deposited within the community containers and removed daily. To avoid double handling it is proposed to replace wheelbarrows by handcarts with large diameter wheels and plastic bins.

Q-6: Please think about the place where most people in your locality bring their refuse and choose the most serious problem:

	Refuse is not removed	Place is very dirty	Place is far away
Gilbert Hill	16 [37%]	19 [44%]	7 [16%]
Bauder Ville	17 [43%]	17 [43%]	6 [15%]

Q-7: Is refuse from your house brought to this place?

	Yes	No
Gilbert Hill	40 [93%]	3 [7%]
Bauder Ville	36 [90%]	4 [10%]

Replies to Question 7 indicate that the majority of people were using the existing storage facilities (in Gilbert Hill) or open areas where refuse was dumped (in Gilbert Hill and Bauder Ville) for refuse disposal. It should also be mentioned that a considerable amount of refuse was finding its way into the small and larger drains in the locality.

Replies to question 8 indicate a healthy attitude towards the use of community bins or designated dumping/transfer areas.

Q-8: Provided that this place is cleaned regularly would you be willing to bring your refuse to this place?

	Yes	No
Gilbert Hill	40 [93%]	3 [7%]
Bauder Ville	40 [100%]	0 [0%]

Questions 9 to 11 were asked to determine the residents' opinions regarding different refuse collection services.

Q-9: What would you think about the idea of sharing a community bin with several families if this bin is emptied daily?

	Good	Fair	Bad
Gilbert Hill	36 [84%]	2 [5%]	5 [12%]
Bauder Ville	38 [95%]	1 [3%]	0 [0%]

Q-10: What do you think about the idea of having a scavenger collect refuse from your house every day?

	Good	Fair	Bad
Gilbert Hill	40 [93%]	3 [7%]	0 [0%]
Bauder Ville	30 [75%]	5 [13%]	4 [10%]

How should this scavenger collect the refuse?

	Knock on door	Blow a whistle	Take refuse from roadside
Gilbert Hill	27 [63%]	6 [14%]	10 [23%]

Q-11. Would you be willing to pay a fee for this service?

	Yes	No
Gilbert Hill	39 [91%]	4 [9%]
Bauder Ville	28 [70%]	12 [30%]

The answers show that the majority (around 90%) would be satisfied to share community storage facilities. Most would also be happy with a house-to-house collection services, but the reasons why ten percent of the Bauder Ville sample were opposed to such a service should be investigated. It is significant that a clear majority would be willing to pay for this service. The reasons for this willingness to pay may include that the road conditions in the Gilbert Hill area are such that there are relatively long distances between community containers. For instance the distance between bins along the main access road was about 120 metres on average (90, 40, 120, 80 and 250 metres). At present the people in some areas of Gilbert Hill have to walk up to 300 metres to the nearest community bin.

Regular removal of refuse from the community was felt to be a basic requirement to improve the hygienic conditions in Bauder Ville. Plans to improve the situation should include a suitable means for refuse storage at the present areas used for crude dumping of refuse.

SUGGESTIONS

- The lack of sufficient storage facilities and regular removal of refuse is considered the main shortcoming in refuse collection in Gilbert Hill. Further investigations are required to identify additional locations for community facilities. The strategy should aim at spacing the facilities as close as possible. However, due to limited access to the area long distances between the containers cannot be avoided in some cases.

- Considering that there seems to be a healthy attitude regarding the use of community bins it is suggested that the public sector should not offer a two-stage collection system. Those who want a more convenient system should employ private contractors to collect the refuse from their households and transport it to community bins.

- The masonry enclosures at Gilbert Hill are in very poor condition and should be replaced by community bins or containers. Because the number of possible locations for community storage facilities is severely limited, larger capacity facilities like skips would be more appropriate than trolleys or pipe bins (see section B- 2.5 (ii)).

The answers indicate that there seems to be no urgent need to consider house to house collection because few complained about the distance to the storage points and almost all were willing to use the community facilities. Therefore the provision of community storage facilities appears to be the most promising approach to improving the present situation.

SUGGESTION: (Bauder Ville) Due to the fact that the public sector is not entitled to provide services in settlements on private property refuse collection by private contractors is considered the only feasible solution. Contracts should include the provision of storage facilities in the community, the regular emptying of these facilities, and the transport of the collected waste to the disposal site. Based on the results of the household questionnaire it is considered possible to introduce a small charge for refuse collection services. Refuse collection, street sweeping and drain cleaning should be combined in a single contract.

Q-12. Have you ever been advised by a person how keeping your neighbourhood clean can improve people's health

	Yes	No
Gilbert Hill	3 [7%]	40 [93%]
Bauder Ville	23 [58%]	17 [42%]

SUGGESTION: It is suggested that public agencies should become involved in carrying out publicity and awareness campaigns in the community. The answers to question 12 indicate that there had been a total lack of publicity campaigns and public health education in Gilbert Hill but that some efforts have been made in Bauder Ville. Possible activities have been suggested in section A-3.5.

Flooding and stagnant water in the drains contribute greatly to mosquito breeding. The influence of disease vectors is addressed in question 13:

Q-13: Please select the most significant nuisance in your locality from the following: flies, mosquitoes or rats.

	Flies	Mosquitoes	Rats
Gilbert Hill	1 [2%]	33 [77%]	9 [21%]
Bauder Ville	4 [10%]	30 [75%]	5 [13%]

The answers show clearly that mosquitoes were considered the most significant nuisance.

SUGGESTIONS

- Considering the fact that sweeping of lanes and drain cleaning are closely interrelated it is suggested that both duties should be combined and that (in government slums such as Gilbert Hill) municipal workers should be assigned (as pairs or individuals) to particular areas for sweeping and cleaning of drains. Adequate handcarts should be provided to these personnel including plastic bins and gloves. Training and strict supervision is

suggested to ensure that all waste collected is be deposited in community containers and removed regularly.

- In private slums, where municipal agencies have no responsibilities, drain cleaning, street sweeping and the provision and emptying of refuse storage facilities should be combined in a single contract. An important reason for this arrangement is that these services are interrelated. (For example, without adequate removal of refuse, littering is likely to increase, so that the burden on street sweepers will increase and they may tend to use drains for disposal of street sweepings. This is likely to cause flooding of public areas, hence cleaning becomes virtually impossible.) The provision of adequate storage facilities and regular emptying of these facilities is considered the most important and should be given priority. Provided that awareness and education campaigns are conducted, it is considered possible to reduce street sweeping and drain cleaning very substantially.

Covering the drains would prevent blockage of drains by refuse and litter. However, this would only be beneficial if *all* drains in an area are covered. Partial covering is likely to increase the problem of blocked and overflowing drains (litter and refuse may still enter the drains but cleaning becomes far more difficult). Due to the cost involved in covering drains this may be considered a medium term objective in case the measures described above prove insufficient.

B-5 OBSERVATIONS IN OTHER HOUSING AREAS

B-5.1 GENERAL COMMENTS

Attempts were made to collect information by means of questionnaires in housing areas that were not slums. The aims were to ascertain opinions and priorities regarding solid waste management and waste recycling.

The results of the survey for middle and high income multi-storey flats indicated that most residents felt that the most neglected service in their area was water supply, followed by stormwater drainage and then refuse. There was often an arrangement whereby private sweepers would collect garbage from houses and dump it in the nearest municipal container. This system does not require any modification
It was further felt that a more elaborate and representative survey is needed to know the requirements, difficulties and aspirations of a broader section of society in these areas. More enumerators would be required to be involved in this exercise and they should be briefed properly before undertaking the survey. The main survey should follow the appraisal of a brief trial survey.

Some results from the survey amongst residents in single-storey flats, apparently in the middle income range, are presented below.

B-5.2 MIDDLE INCOME GROUP: SINGLE-STOREY FLATS (DN Nagar, Andheri)

The analysis of responses regarding the most neglected or inadequate services is given below:

	Water supply	Toilets	Stormwater drainage	Refuse	Roads	Electricity
First priority	7 [58%]	1	1	2	1	0
Second priority	2	4 [28%]	3	4 [28%]	2	0
Third priority	1	1	5 [35%]	4	1	2

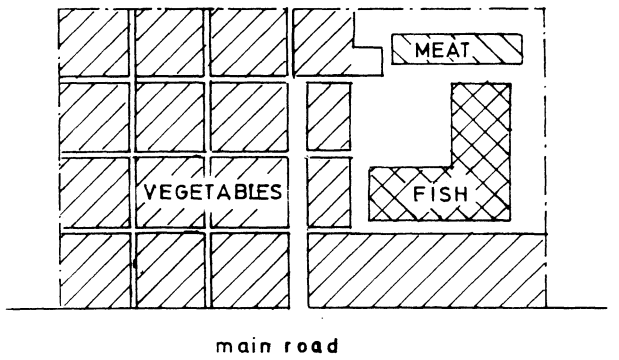
This sample indicates that inadequate water supply is seen as the most serious problem in this locality, followed by toilets, refuse and stormwater drainage. Most of the people expressed the opinion that the toilets were very dusty. It was also learned that the refuse was taken to the community collection point either by the father or a house servant.

Most of the people said that flooding of drains was a serious problem. It appears that drain cleaners were not functioning properly in this area.

B-6 MANAGEMENT OF MARKET WASTES

The collection of market waste from the Andheri Municipal Market was studied. This market is the largest of the five markets in K-West Ward - two of the markets are municipal and three are private. There are 401 small stalls in Andheri market including a large vegetable and fruits section (105 stalls), hardware and hosiery shops. The meat and fish section of Andheri Market is located in large sheds. Access by vehicles is only possible along one larger lane in the centre of the area. The remaining lanes are narrow and designed for pedestrians only. Figure B-6.1 shows a very approximate layout of the market.

Figure B-6.1: Approximate layout of Andheri Market



Andheri Market including all facilities and structures is owned by MCGB.

B-6.1 ORGANISATION AND MANPOWER

The Market Superintendent, in the Market Section of the Ward Office, is responsible for management and supervision of the markets.

One market supervisor and four market inspectors are permanently assigned to Andheri Market. Their tasks include supervision of ten sweepers who are responsible for refuse collection, sweeping of lanes. and cleaning the fish and meat market. In addition two lavatory cleaners are assigned to the market. Primary collection and storage of market waste is under the responsibility of the market section.

Sweeping and market waste collection were carried out in two shifts. Seven sweepers worked in the morning shift (7 am to 2 pm) and the remaining three sweepers worked in the

afternoon shift (3 pm to 11 pm). According to the Market Inspector the area is cleaned twice daily, 7 days per week. The waste collected in the market is stored in one refuse shed (see ii below). Transport of market waste is carried out by a contractor's vehicle for the SWMD (starting daily at about 6.30 am).

The charges for market waste collection and sweeping varied according to the size of the stalls, ranging between Rs 30 and Rs 100 per stall monthly. Another Rs 30 to Rs 100 was charged as rent for the stalls.

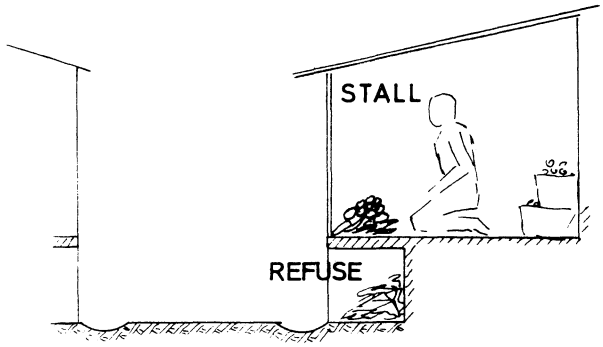
COMMENT: The present system seems to be functioning well and no problems regarding co-operation between the Market Section and the SWMD were reported.

B-6.2 PRIMARY COLLECTION OF WASTE FROM STALLS

Market waste from stalls was collected twice daily by the sweepers. The crews were equipped with brooms for sweeping the lanes and wooden boards for loading the waste into handcarts. Equipment was stored at the market chowki and issued to the sweepers daily.

According to the market supervisor between 3 and 4 tons of waste were generated in Andheri Market per day (including the fish and the meat section).

Figure B-6.2: Typical lane in Andheri Market



As shown in the figure vegetable waste was usually stored below the stalls and must be loaded manually into the handcarts. Hence, removal of vegetable waste and cleaning of these locations is difficult and labour intensive. Transport of market waste was carried out using two type A handcarts (see figure B-2.4). Each cart was equipped with two cane baskets with a capacity of up to 70 litres each. Considering that the refuse density may be about 0.5 kg/litre the handcart load would be only 70 kg. However, it was observed that the cart was very difficult to push in lanes with uneven surfaces and that the sweeper pushing the cart needed help from a second person pulling a rope which was fixed to the cart.

SUGGESTIONS

- To improve storage and loading of market waste from the stalls it is suggested that adequate storage facilities should be introduced. Interviews with some of the stall owners showed that the majority would be willing to co-operate with the market department regarding more adequate means for storage of refuse. Cane baskets or plastic bins are considered appropriate and should be provided by the individual stallholders. It was observed that larger shops along the main road already kept bins or baskets for storage of refuse.

- Regarding handcarts, it is suggested that their capacity should be increased according to the concept described in section B-2.4 above. The provision of plastic bins would be far more suitable for storage of vegetable, fish and meat waste. In addition, the carts should

be equipped with larger diameter wheels to allow for handling by a single person on uneven surfaces.

The measures described would probably allow a reduction in the labour force for market waste collection in Andheri Market.

B-6.3 COLLECTION OF WASTE IN THE FISH AND MEAT SECTION

Waste from the fish and meat section is highly objectionable and therefore requires careful consideration. The stalls usually dumped their fish waste on the ground and the small heaps were either brought to the shed-type storage facility of Andheri Market or hosed down the drains twice daily. At the time of the study there are no bins or bags used in the fish market.

The drainage system in the fish market consisted of a network of open drains which were connected to manholes and sewers. Apart from the nuisance caused by foul smells, the practice of discharging waste to the drains is likely to cause other problems, especially the blockage of sewers, and flooding during the monsoon season.

SUGGESTIONS

- Being aware of the problem, the Market Section was planning to introduce plastic bags for storage of waste in the fish market. It was planned to charge about Rs 2 per stall daily for the provision of bags. Considering that this would add up to another Rs 60 per stall each month, this option may be not economically feasible.

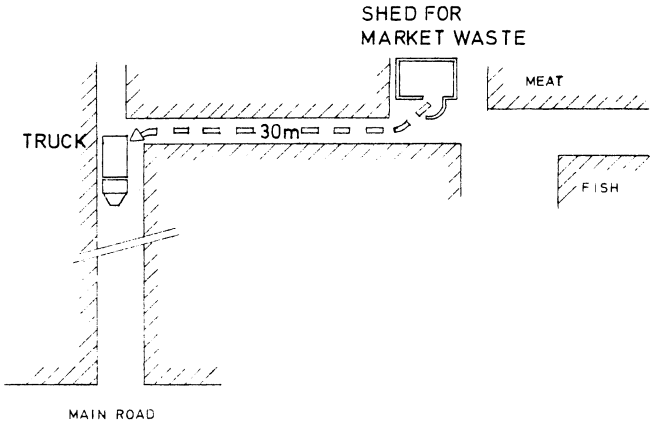
- Another option may be the provision of several plastic bins (with lids) which could be used by groups of stalls (say about ten). Provided that these groups could be made responsible for cleaning and keeping the bins overnight this option may be more reliable and far cheaper than the provision of plastic bags. The bins could be kept outside the shed to allow for easy emptying by the sweepers.

- In addition it would be desirable to cover open drains in this area and to provide screens at the inlets to manholes. If screens are provided it is essential that they be cleaned regularly, otherwise the small and flooding nuisance would be even worse.

B-6.4 SECONDARY STORAGE AND COLLECTION OF MARKET WASTE

As already mentioned above one refuse shed is used for storage of market waste from Andheri Market. A ground plan of this masonry structure is shown in Figure B-6.3.

Figure B-6.3: Refuse shed for storage of market waste



Market waste is tipped to the floor of the building and has to be loaded manually into the refuse collection vehicle. It is shown in the figure that there is no direct access for the vehicle and therefore the loaders have to carry waste some distance from the shed to the collection vehicle.

COMMENT: The existing storage practice is considered very unhygienic. Waste accumulates on the floor of the building, inviting flies and creating bad smells in close proximity to the stalls. In addition the location is considered very unsuitable because it does not allow for direct access for the collection vehicle.

SUGGESTIONS

- It is therefore suggested that the shed should be removed and containerised facilities should be provided instead. For instance, a refuse skip, provided with lids and placed at a location close to the main road, is considered suitable. However, because the skip system had not yet been introduced to K-West Ward, trolley type containers could be used for an interim period. Twice daily emptying would allow the numbers of containers to be kept to the minimum and reduce the development of bad smells. Storage facilities in markets are primarily used by staff of the market section; provided that these personnel were trained and supervised so that they always replaced the lids of containers, this would improve the hygiene status of the markets considerably.

- The provision of containerised storage facilities to markets is considered a priority measure and further investigations are suggested to assess the situation.

PART C

COLLECTION AND TRANSPORT IN K-WEST WARD, BOMBAY

LIST OF CONTENTS

C-1 INTRODUCTION

Most of the solid waste from K-West Ward is collected by two types of vehicles: - compactor trucks owned by MCGB and open trucks (without tipping gear) which are operated by contractors, and which are rented to MCGB with a driver. Tractors and trailers are also used for collecting waste from the beach, and there are some MCGB open tipper trucks.

The compactor trucks are constructed entirely in India, and are of the rear loading type, with hydraulically operated packer and ejector plates. They are also equipped with hydraulic lifting gear to lift and empty specially designed trolley bins. Each driver of a compactor truck is accompanied by a cleaner, who generally operates the loading and compacting systems. Three of the vehicles deployed in each shift in K-West Ward are MCGB compactor trucks.

The contractor's trucks are generally old. Their bodies are mostly of wooden construction, with a small section between the cab and the waste-containing part, presumably for the crew to travel in. The height of the trucks is such that they must be loaded by passing the waste up to one or two men standing in the back of the truck.

For the first shift the vehicles are due at the motor loader chowkies at 6.30 am. Beats (routes) are assigned by the Junior Overseer (JO). Normally in each shift one vehicle makes only one trip from the ward to the dumping ground. The morning shift is from 6.30 am to 1.30 pm and evening shift is from 2.00 pm to 9.00 pm, (up to supervisor level, seven days a week; a rotation system allows the labourers one day off in seven). One vehicle also operates a night shift from 10 pm to 6.00 am for collecting refuse from certain markets. For attending to emergency calls three vehicles with crew are available at the central control room in 'B' Ward under a JO during the night shift. The refuse of K-West Ward is unloaded at the Chincholi disposal site (at Malad) which has no lighting facilities.

The loading team that is collected from the motor loader chowki comprises six motor loaders and one mukadam for each vehicle. If any of the motor loaders are absent, men are appointed as stand-in motor-loaders from among a reserve of casual labourers, on a daily wage basis.

This part of the report is concerned with vehicle operations. Data on operations were collected by following different trucks, observing the operations and noting the times taken and the quantities of waste handled. From this information the costs of collection of refuse by different means are estimated, and suggestions are made regarding possible improvements that should be examined further. Data were also collected from the vehicle workshops, to gain an understanding of the problems relating to keeping the vehicles in good condition.

C-2 STUDIES OF VEHICLE OPERATIONS

C-2.1 WORK STUDY MEASUREMENTS

Work study aims to identify the most efficient ways of performing a task and improve on them. Observation and measurement are the two main components of work study - observation suggests ways of improving methods, and measurement of times, distances, quantities and expenditures enables the calculation of costs so that the most economical method can be chosen. Comparison of costs is only meaningful if the costs are on a unit basis, such as costs per cubic metre or per tonne of refuse, because different methods generally relate to different quantities of waste.

Operations were studied by following refuse collection vehicles for the whole of a shift, and noting down times, quantities and distances, and observing methods and problems. This procedure was repeated for four shifts. The information that was recorded is reproduced in Appendices CC-I.1 to 4. Observations during this study were made with the full knowledge of the crew that was being observed, so it is likely that certain of their practices were modified because they were being monitored. To some extent this effect can be compensated for by adjusting recorded values (for example, if it is judged that labourers are working faster than normal, measured times for operations can be increased when used later in calculations). In this case, time is not as important a factor as it might be in other situations because the crews are accustomed to completing only one load per shift and so their output is not determined by the time taken.

Calculations of unit costs had already been performed by DCE Shri Panjwani of MCGB. A summary of his calculations are reproduced in Appendix CC-II His calculations showed that the transport cost per tonne is the least for the dumper placer system (Rs 65 per tonne), as compared with Rs 130 per tonne for compactors and Rs 235 for open trucks.

A computer program (known as *SENS*), based on a spreadsheet, has been developed at WEDC, Loughborough University of Technology, for calculating unit costs of collection systems. This program has been used in this case, and the calculations are shown in Appendix CC-II.2. *SENS* can also be used to investigate the effects of changes, to determine the sensitivity of the results to variations in any particular item of data and to estimate the costs of modified systems.

(i) Compactor trucks

The calculations shown in Appendix CC-II.2 and the computer program give the following results:

Table C-2.1 Unit cost results for compactor trucks.

Situation for which costs estimated	Costs Rs/ton
Compactor truck A, observed 25 November 1992	218
Compactor truck B, observed 30 November 1992	206
MCGB data	138
Proposed alternative	191

The first two situations are apparently the same, but the costs differ by 6%. However, they give an approximate value for the cost of collecting a tonne of refuse under the present conditions. The MCGB data is based on data used in the calculations of Appendix CC-II.1, where the cost was calculated to be Rs 130 per tonne. The small difference between the result here and the result calculated by MCGB (i.e. Rs 138 compared with Rs 130) is caused by the inclusion of the costs of the trolley containers, and minor differences in the methods of calculation, and errors caused by assumptions such as assuming every month to have 30

days. (If the price of the trolley bins is set to zero - meaning that they are ignored - the estimate for the cost per tonne using *SENS* is Rs 122.)

Though these three results are for the same situation, the differences are great, largely because of the different wage rates that are used. It appears that costs and wages have increased considerably since the MCGB calculation. Other differences are caused by the inclusion of the costs of the trolley bins for the first two cases, and the consideration of vehicle availability.

Calculations for A and C indicate that labour and supervision costs account for approximately 56% of the total cost; it is therefore important to try to keep these to the minimum. The proposed alternative does this by allowing the work to be done by a smaller crew. This alternative depends on improvements to the maintenance of the trolley bins, and on paving of the ground on which they stand. Such improvements would allow a smaller workforce with each truck, since a bin could be moved by a smaller team if all its wheels were in good condition and if it were rolling on a hard, smooth surface. This calculation also assumes that all of the waste is in the bins; this would need co-ordination with the street sweepers to ensure that the area was clean before the truck arrived. Some control over the rag pickers would also be of assistance to prevent the scattering of waste before the arrival of the collection truck. The saving in cost is in the region of ten percent.

Another advantage of the proposed alternative mentioned above is the reduction in the time needed to do the work. In this case the collection vehicle would be in use for less than 10 hours, instead of eleven to twelve. A further improvement would be to operate three shifts per day. If the mukadam and the cleaner would be willing to help move the trolleys when needed, and if three shifts were worked each day, the cost per tonne is reduced to Rs 162; if the life of the truck is reduced from ten years to seven years because of the extra wear and tear caused by the extra shift, the cost per tonne becomes Rs 169 - which still represents a saving of twenty percent.

Whenever changes to working practices are proposed, it is important to anticipate the likely reaction of the workforce, and to try to find ways of making the changes agreeable to them. It may be possible to persuade the workforce to accept such changes if they are paid the same amount for a shorter shift, and if the advantages of cleaner working conditions (i.e. no loading of refuse from the ground) are clearly presented to them. If three shifts are worked, some labourers might wish to work for two shifts each day to increase their income, or alternate, working one shift three days each week and two shifts on the other days. There may be particular resistance from the mukadams to returning to some manual work, but a small pay increment, and the fact that they would not be required to sweep or shovel refuse, but only to help move the trolleys, should help them to accept these changes. The need for supervision becomes less when there are only two labourers. There may also be problems in persuading the vehicle cleaner to help, but as his work involves so little activity, a small pay incentive may be sufficient (if the managerial problems of asking an employee of the transport section to do conservancy work could be overcome).

The key to reducing costs is to reduce the workforce, but this presents many problems because of trade union pressure to maintain the existing establishment. Redeployment of some of the workforce may be an option.

The advantages of the proposed modifications in terms of hygiene and the environment are considerable, since there would be no skin contact with the waste, and no waste lying on the ground.

(ii) Open trucks

The operation of two open trucks was studied. The data collected are in Appendices CC-I.2 and CC-I.4, and the input data are discussed in Appendix CC-II.3. The results from the *SENS* program are shown below.

Table C-2.2 Unit cost results for open trucks

Situation for which costs estimated	Cost per tonne [Rs]
Contractor's truck B 26 November (SENS)	381
Contractor's truck D 2 December (SENS)	298
Municipal open truck (MCGB data)	222

The first observation from the results above is that municipal operation of open trucks seems much more economical than the hiring of vehicles from contractors. This, however, is not the case, as is shown in table C-2.3 below. The reason for the large difference between the costs for B and D and the municipal vehicle in table C-2.2 above is in the data - the salary levels in the MCGB data are much lower than those used for the contractor's trucks. In order to examine this comparison, calculations were made for a municipal open truck using wages data similar to that used for the contractor's and compactor trucks. The life span of the open truck was increased to 15 years and the availability to 80%, both because open trucks are considerably simpler and more robust than compactors (for which the values were 10 years and 67% respectively). This result is compared with others in table C-2.3 below.

Table C-2.3 Unit cost results - comparisons of type and calculations

Type of vehicle	Average unit costs [Rs/tonne]	
	SENS program	MCGB calculations
Compactor	**212**	**130**
Municipal open truck	**389**	**235**
Contractor's open truck	**340**	**-**

The results here show that municipal operation of open trucks would be more expensive than the use of contractors' vehicles (in contradiction to the apparent conclusion from table C-2.2), and that both are very significantly (83% and 60%) more expensive than compactor trucks.

The difference between *SENS* and MCGB results is thought to be largely because of differences in wages: - Rs 1500 per month was used for MCGB calculations and Rs 2500 per month for *SENS*. The importance of the wages component is shown in table C-2.4 below.

Table C-2.4 The relative importance of wages and supervision costs

Type of vehicle	Method of calculation	Percentage of total cost that is wages and supervision
Compactor truck	MCGB	56
	SENS	62
Open municipal truck	MCGB	66
	SENS	72
Open contractor's truck	*SENS*	75

The results in this table show that the greatest impact on cost reductions can be made by reducing the wages bill.

A final conclusion, and one that has potentially a great impact on operating costs, is that there may be a considerable advantage in weighing the loads, or weighing a significant proportion of them at random. It is difficult for the JO at the checkpoint to verify visually whether each truck has been loaded to a satisfactory degree, because of the rush at the peak periods, because of the lack of parking spaces within view from the check point, and because the sides of the trucks are high and so it is not possible to judge the height of the central portion of the load. As a result, vehicles may be completing their loading and going to the disposal site with less than a full load. This was demonstrated very clearly by the observations of vehicle D. The observer was told that the crew had finished loading and was going to the disposal site. At this point he asked them to go first to the weighbridge to weigh the load. On hearing that the load was to be weighed, the crew or the mukadam decided that the load might be found to be too small, so they went to two more loading stations in order to increase the load that they were collecting. The extra load that was added was estimated by counting the number of bowl-loads that were put in; on this basis it was calculated that they added a further 62% before going to the disposal site. Table C-2.5 summarises the situation. The savings in unit cost terms is dramatic.

Table C-2.5 The effects of weighing on loads and costs

Parameter	**Initial - the situation that would have applied if weighing had not been required**	**Final - what was actually achieved because the load was to be weighed.**
Volume collected [m^3]	6.9	11.3
Weight of load {tonnes]	2.4	3.9
Unit cost [Rs per tonne collected]	**480**	**298**

C-2.2 GENERAL OBSERVATIONS

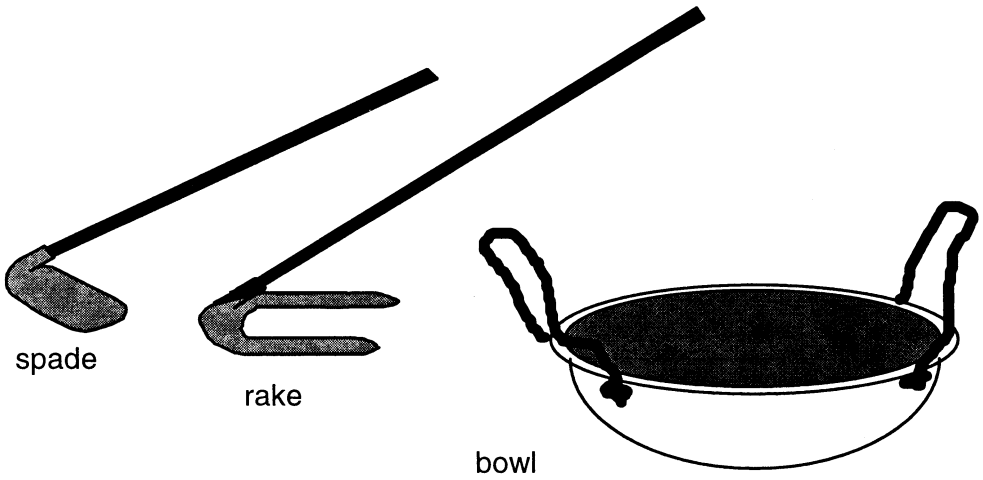
In solid waste management there is great benefit in observing operations to determine how the performance of tasks could be made more efficient or less hazardous. Observations often support the view that the *little things* are important, i.e. that attention to detail and the correction of seemingly small shortcomings can lead to comparatively large savings. There is also often great benefit in listening to the workforce at all levels to learn their opinions about factors that might be hindering the work. The aim of this section is to mention and discuss some of the minor observations that were made during the course of the study - observations which complement the quantifiable matters discussed in the previous section.

(i) Operations

The method of loading solid waste from the ground into either open trucks or compactors is impressive. It is clear that considerable thought has gone into the tools and techniques for this operation, and the results are clearly demonstrated in the speed at which waste is collected up and loaded. This speed and efficiency appears to be due to two factors: the tools that have been provided and the motivation of the workforce.

Each team is normally provided with two rakes, a spade, two brooms and a bowl. (One team of loaders that was observed had only one rake, and appeared to be operating less efficiently as a result.) Figure C-2.1 shows the types of tools that are used. The bowls are made of plastic, have rope handles, and can hold over sixty litres of some types of waste.

Figure C-2.1 Tools supplied to motor loaders
In addition brooms are provided, such as that shown in figure B-2.2(a)



The bowls have been developed using field trials, and are the key to the efficient loading of the vehicles. They cost Rs 600 each (in 1992), and are the item of equipment that causes most problems regarding replacement. They are said to have a useful life of 6 months. Some crews were seen to be using bowls that were partially broken; this would indicate some problems in providing replacements at the motor loader chowki.

The brooms that are used are a simple type which can easily be repaired, but their life was said to be only 20 days.

The crews working with compactor trucks are issued with steel 'T' bars for pulling and steering the trolley bins. These also cause problems because their normal life seems to be about 6 months, and some that were in use appeared damaged.

There was some evidence that the process of acquiring replacements for broken tools could be very lengthy, since tools were obtained from the AHS, the request going via the mukadam and the JO. If the supply of such minor items could be speeded up, perhaps by keeping a small stock at the motor loader chowki, there would be improvements in morale and efficiency.

At the beginning of each shift a roll call was taken by the Junior Overseer. It has been known, amongst large labour forces, for employees to be paid without actually appearing for work. Whilst there was no evidence that this was occurring, it would be possible for one person to answer to more than one name. The JO said that he recognised the voice of each loader, but with a large workforce this could prove difficult. It appeared that absentees were not marked as absent, but the space in the register was left blank. Such a practice might encourage later fraudulent entries to be made by unauthorised people, so it would be better if a clear mark were made after the second call to indicate that a particular man had not attended.

Some traffic congestion was caused by all the trucks parking near the chowki, but no simple solution was apparent.

The records at the motor loader chowki were well kept, and provide useful summaries of each day's work. Further extracts from these records are shown in Appendix CC-I.5

The motivation of the crews appeared excellent - they worked together well as a team, with each loader actively engaged, and they worked efficiently. This standard of work may have been because they were being observed, but the fact that their work for the day is over when they have finished one load encourages them to work well. (If loads were weighed more frequently there would be less chance of the crews stopping the loading before a full load had been collected.) The time when the morning shift is usually over can be compared with the time recorded when under observation to determine whether the crews were working faster when observed. The table in Appendix CC-I.5(i) shows that the usual arrival time at the disposal site is later than the time recorded during the observation. (On more than half of the twelve days for which the records are presented, the vehicle is logged in at the disposal site at 11.30 or later, whereas during the field observation the vehicle arrived at the disposal site at 10.58, after having made the extra visit to the weighbridge. In the twelve days for which records are shown, the truck arrived at the disposal site only once at 10.50, and once at 11.00 am.) This comparison suggests that the loaders may have been working a little faster than normal when under observation, which is entirely normal and to be expected. The records also show that unloading a compactor truck usually takes 10 minutes.

One of the compactor trucks was observed shedding dusty material and chippings from coconut shells through the gap between the hopper (tailgate) and the body. This shortcoming was therefore causing environmental pollution and adding to the loaders work as they needed to sweep up the material that fell through the gap during the compacting cycle. It might be possible to weld extra steel plates to the bodies or tailgates to prevent this happening.

It is not known how the wheels of the compactor trolleys become broken, but it was observed that the emptied trolleys were dropped onto the ground relatively quickly, so that the wheels were subjected to a considerable shock. It might be possible to reduce the incidence of broken trolley wheels by slowing the rate of descent of the loading mechanism by means of a constriction in the hydraulic system, or by training the operators to lower the trolley bins more gently.

The number of employees with each compactor truck - nine - is very high (driver, mukadam, cleaner and six loaders). Of these the cleaner does the least; he usually (but not always) operates the loading and compacting mechanism, but does little else during the collection round. Whilst it is understood that he is from the transport side of the MCGB, and not the conservancy side, and that the law requires a cleaner to accompany the driver of a heavy vehicle, it might be worthwhile to find ways of integrating the cleaner to a greater extent.

Some hotel waste was very unpleasant to load because it was very wet and it was not containerised. At one hotel the loaders were obliged to walk over the waste. On one occasion a plastic bag containing wet waste burst in the compaction mechanism, shooting a jet of waste over a distance of more than five metres. The ideal solution would be to find a way of utilising this waste, and that it should be collected separately, being kept in the same containers during both storage and transport. Considerable dripping from the truck was noticed after this waste had been loaded.

In most of the open trucks the full loads were covered before the vehicle set off to the checkpoint. This is a commendable practice, and the high degree of compliance with the instruction to cover the loads in open trucks is greatly to the credit of the supervisory staff. It was noted that covering the load with gunny took about two to three minutes.

Weighbridge results showed that the compactors may often be overloaded on the back axle. This is a common problem all over the world; the consequences can be road damage (in the

case of excessive overloading) and vehicle problems. The Maintenance Engineer at Santa Cruz mentioned that there had earlier been failures of the wheel studs, but that these had been cured by the fitting of stronger, ten tonne axles. The incidence of broken springs should be monitored to check whether overloading is causing significant problems in that way.

(ii) Health and safety

Skin contact The most obvious health hazard faced by the loaders is because of the skin contact that they have with the waste. Studies in India and Egypt have shown that refuse workers have a higher than average incidences of intestinal parasites; such parasites are present in faeces and can penetrate the skin. Loaders are at risk when they handle the waste without gloves or when they stand in the waste. A loader may be at risk when he props a bowl up against his leg in order to rake waste into it, or when he stands in an open vehicle, either to receive the waste during loading, or when the vehicle is moving, but the most hazardous activity is when open vehicles are unloaded manually, since the labourers are often standing in piles of waste that they have pulled off the truck and over their feet. Generally motor loaders wear only plastic slippers on their feet; these slippers provide some protection for the sole of the foot but none for the rest of the foot or the lower leg. Motor loaders rarely touch the waste with their hands since their tools are adequate for the tasks they are required to do.

The other hazard of skin contact is the danger of cuts caused by sharp objects such as glass fragments, razor blades, tin cans and, most importantly, hypodermic syringes. Not only is there the risk of cuts, but there is the more serious risk of infection from germs that enter through the cut - a risk that is particularly serious from syringes containing blood that is contaminated with HIV or hepatitis viruses.

The solution appears simple, namely to provide the labourers with rubber boots. There may be some problems in ensuring that the labourers wear the boots, and there may be incidences of labourers selling such equipment. More information on experiences of previous attempts to provide protective equipment and on the attitude and understanding of the workforce would help to determine how a scheme to provide boots should be managed. The boots provided to labourers who unload open trucks should be high enough to prevent any skin contact with the unloaded waste.

Traffic accidents Refuse collectors are always at risk from traffic accidents, but two practices were observed that pose special risks. The first involved the manoeuvring of trolley bins into position for loading - the labourer who was pulling the handle and steering the trolley was obliged to go ahead of the trolley into the road and was thus vulnerable to collision with passing traffic. The danger was particularly acute when trolleys with broken wheels were being moved, since the loaders would have less control over the movement of the trolley - it might suddenly move after resisting previous efforts. The risk can be minimised by ensuring that all trolley bins are kept in good condition and on paved surfaces, and by training and regular reminders for mukadams and labourers.

The contractors' vehicles usually have a small compartment between the cab and the refuse storage area for the crew to ride in. Sometimes it was used for storing a spare wheel, but some crews did not ride here. Some loaders rode on top of the cab - a very dangerous place to be in the event of sudden braking or a head-on collision - and others rode in the back with the refuse - a dangerous place because of the risk of falling off and because of skin contact with the waste. It would be worthwhile to ascertain from the crews why they do not ride in the crew compartment and to try to find ways of transporting the crew more safely.

Compactor trucks can accommodate more loaders in the cab, but for short journeys between collection points, loaders sometimes travel on the hopper - a very dangerous practice. The provision of steps and handles at the rear of compactor trucks (to allow loaders to travel short distances more safely) would be a reasonable compromise.

Rats build their nests in untidy areas where they will not be disturbed. If trolley bins were used more widely, collection points were paved, and solid waste was not left on the ground for more than a few hours, there would be fewer places for rats to hide and so control of rat numbers would be easier.

Regular medical examinations Some of the motor loaders mentioned the lack of medical check-ups as a problem, one saying that he had not had one for three years. It is suggested that each motor loader be given a free medical examination each year for the following reasons:

- employers have a moral responsibility for effects on the health of their employees that are related to their work;
- the provision of some medical care is a helpful motivating factor because it indicates to the labourer that his employer is concerned with his well-being, and solid waste workers are often worried about their health because of the risks of handling refuse;
- healthy labourers work more efficiently
- medical examinations can be used to generate statistics relating to the work - these statistics may be helpful in quantifying benefits of, for example, providing protective footwear or changing the loading or unloading methods.

C-3 VEHICLE MAINTENANCE AND AVAILABILITY

C-3.1 INFORMATION FROM THE MAINTENANCE ENGINEER

The central garage is Santa Cruz, and there are seven vehicle depots. One of these depots is Bandra, where the vehicles that work in K-West Ward are kept. There are 491 vehicles under MCGB management at Santa Cruz for a variety of municipal purposes; they are not kept at Santa Cruz, but are sent there for major repairs and maintenance.

There are two Executive Engineers responsible for transport, one for the city area and one for the suburbs.

Work done centrally at Santa Cruz includes accident repairs, preparation for the annual *RTO* test, servicing, springs, axles, body building and painting, and rebuilding of *units* - (that is, engines, gearboxes, dynamos, and radiators. These units are exchanged for faulty units which are fitted at the depots.) The main stores are at Santa Cruz, and the depots have sub stores which hold only a small number of fast-moving parts.

Machining work is done by outside contractors. Parts are purchased from authorised dealers without going out to tender each time. The Maintenance Engineer has an imprest of Rs 40,000; he has the authority to sanction expenditure of up to Rs 3,000 and can make cash purchases of Rs 400 at a time. The Maintenance Engineer is on the Technical Committee and so has an input into the selection of new vehicles.

The municipal vehicles are not insured, but there is a Rs 12 lakh reserve fund, which must be made up to that level every year by the end of March. The staff, including drivers and cleaners from all depots, totals 1348 people, and the monthly salary bill is Rs 50 lakhs. The

annual maintenance budget is around Rs 4 crores. (As a rough guide, the maintenance expenditure on a vehicle over a ten year period is equivalent to its capital cost.)

Entry to the workforce is as a labourer, cleaner or driver, with a 9th standard education. Labourers can progress to become Fitter II, then Fitter I, then Mechanic and on to Assistant Foreman, Foreman and Auto Technician. The turnover of the workforce is very little - staff like the security and pay.

Passenger vehicles are considered to have a seven year economic life, and larger vehicles a ten year life. However, 45% of the current vehicles are over ten years old, and some are thought to be as old as 25 years. (In 1986, two-thirds of the fleet was over ten years old.) The procedure for auctioning old vehicles takes about one year. The Scrap Committee decides on the minimum price, and if this price is not reached in the auction, the vehicle may be rehabilitated.

In the case of simple vehicles, 20% extra vehicles are purchased to act as standby's; for compactors the figure is 25%. Five spare engines are kept as standby units for every hundred held.

All vehicles are powered by diesel engines; it has been a policy decision that no petrol engined vehicles should be used. This policy enables fuel savings because of the higher efficiencies of diesel engines, and allows the mechanics to specialise.

C-3.2 DISCUSSION AND SUGGESTIONS

Enquiries showed that a good system of record keeping had been developed. The only area that was identified in which record-keeping might be improved is in the area of recording costs of repairs and operational costs for each vehicle. Such records could be of assistance in determining the economic life of the vehicles, and of identifying particular shortcomings of certain vehicles or certain types of vehicle.

The chart below (figure C-3.1) shows the time that was spent on the different types of maintenance for compactor vehicles in November 1992, based on data in Appendix CC-III.2. It shows that most time is spent on chassis repairs - three times as much as is spent on body repairs. This suggests that the chassis (motor, transmission, springs etc) have more problems or that the chassis repair crews have so much work that they cannot attend to new work without a considerable delay. This suggests that it might be worthwhile to study the type of fault to determine what action could be taken to reduce the downtime caused by chassis faults - such as changing the chassis specification, providing further training for the drivers or studying the operation and requirements of the repair workshop. Appendix CC-III.3 gives some more information about the types of faults encountered during a short period. The time required for preparation for the annual test seems to be considerable, taking nearly ten percent of the vehicle's time during the month in question; if that time could be shortened there would be a noticeable improvement in the availability.

Figure C-3.1 Availability and relative time spent on different types of repair, November 1992

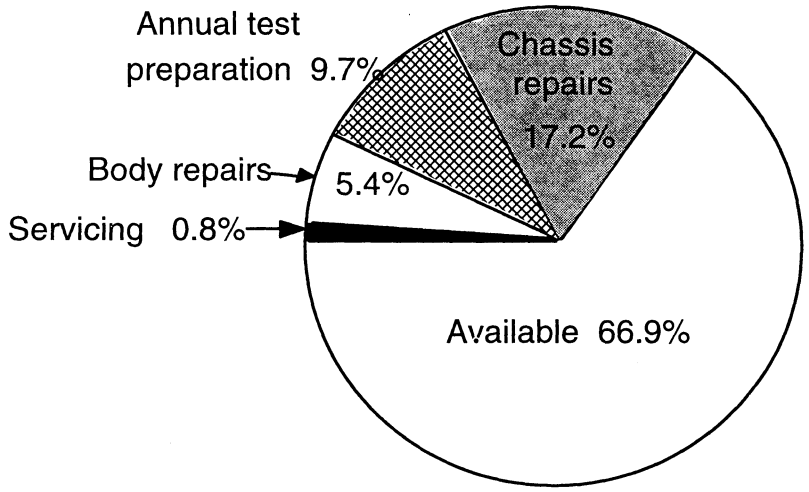


Figure C-3.2 shows the length of time that different maintenance tasks require. For example, it shows that routine servicing in November, which was undertaken on three occasions, took no more than 2 days on each occasion, whereas, on two occasions work relating to the annual test took more than 14 days.

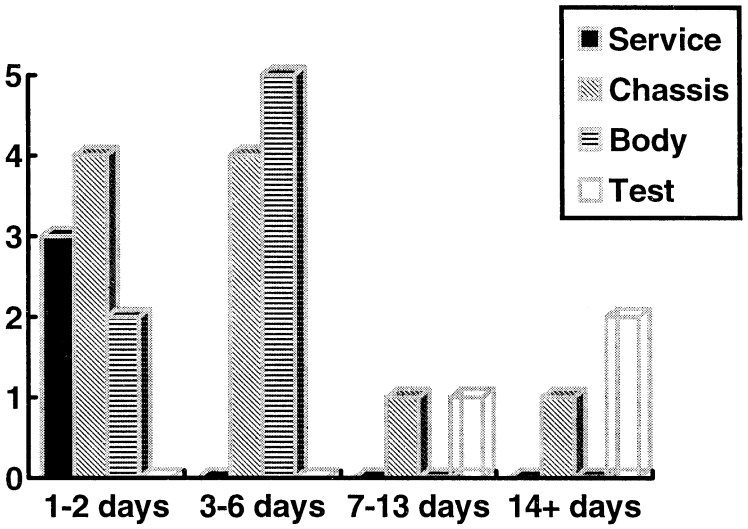
The results for figure C-3.2 are taken for only one month (based on data in Appendix CC-III.2); repairs that were started before the beginning of the month, or may have continued after the end of the month cannot be included on the basis of the information in the Appendix, since the total duration of that particular incident of downtime is not known. However, this method of presentation may prove useful if based on more extensive data, as an indication of how long vehicles are off the road for different reasons.

The support of the Airtech repair team, based at Bandra, is clearly very useful in keeping the compactor trucks operational. It is suggested that a programme for the repair of the trolley bins be developed. Repairs could be done by a mobile crew, if the locations of defective bins were reported by the mukadams. Otherwise defective bins could be brought in to a depot (after having left a satisfactory bin to replace the broken one) by a special vehicle and crew. The third possibility is to have a trolley bin repair crew in each depot that has compactor trucks, with some mechanism of encouraging each compactor truck driver to pick up a defective bin on the way back from the disposal site. Each defective bin that is brought in for repair would need to be replaced by a sound one; perhaps this could be done by maintaining a few good trolley bins at each motor loader chowki, so that when one was used to replace a damaged bin, it could be replaced the next day by a compactor truck bringing a repaired bin from the depot. Incentives and supervision would be very important in ensuring that trolley bins are well maintained.

The maintenance of the municipal vehicles for Greater Bombay is already a huge task. If there were more municipal refuse collection trucks, and fewer contractors' trucks, the scale of the operation would need to be even larger.

Figure C-3.2 The frequency of the duration of different types of maintenance work

Note: The vertical axis shows the number of repairs, begun and completed within the month of November, that lasted for the period indicated.
Service means routine servicing
Chassis means repairs connected with motor, transmission, axles, cab etc
Body means repairs connected with the loading, compacting, containing, and ejecting systems
Test means work connected with the annual RTO test.



PART C

APPENDICES

APPENDIX CC-I WORK STUDY OBSERVATIONS

Notes: The data below were collected while following collection vehicles; the original notes have been edited but are in a form similar to the original record. The distance meter readings are taken from the meter of the observation vehicle that was following the truck, and the time is clock time in hours, minutes and seconds.

Station denotes a loading point or storage facility

Arr denotes the time when the vehicle arrives and stops at the storage facility that is to be emptied.

Dep denotes the time when loading at the particular location has been completed, and the vehicle moves off.

No. of bowls Solid waste that is not loaded directly into the truck by the hydraulic system of a compactor truck is loaded using large plastic bowls with rope handles. Though the actual volume of refuse placed into such bowls varies considerably, the number of times that bowls must be filled to clear the waste is an indication of the quantity of the waste and of the time of the operation. At first the numbers of bowls were not counted; these occasions are marked thus *.

Trolley a wheeled container specially designed for Airtech compactor trucks, of capacity 1 m^3, as shown in figure B-2.11

CC-I.1 Compactor truck - 'A' -, 25 November

Vehicle model: Airtech Schörling 4R, approximately three years old
Total body volume approx. 12m^3 (Appendix CC-I.6)

Station	Distance meter (km)	Time	Notes	No. of Bowls
	304	7.19'	**Start** (Tools carried in hopper)	
1	305	7.23'	**Arr** (One trolley behind pile which must first be cleared with bowls. Loading cycle takes about 44 s. Emptying trolley takes 111 s.	*
		7.39'30"	**Dep** (One loader rides on vehicle)	
2	305	7.40'30"	**Arr** (Little waste around. Trolley missing one back wheel. Trolley emptied in 40 s.)	*
		7.43'30"	**Dep**	
3	306	7.45'	**Arr** (Trolley ¾ full. Waste around very wet)	*
		8.00'	**Dep** (Backing out of site - roadworks)	
4	307	8.04'40"	**Arr** (Trolley full. Coconuts picked up by hand; dead cat thrown in, 6 men needed to move trolley; cycle to empty trolley took 99 s.)	*
		8.11'45"	**Dep**	
5	308	8.13'40"	**Arr** (Trolley approx. 20% full; also masonry bin; trolley had no front wheel, could not be moved.)	6
		8.17'40"	**Dep**	

compactor truck - 'A' - continued

Station	Distance meter (km)	Time	Notes	No of Bowls
6	308	8.20'00"	**Arr** (2 trolleys 1 very full, 1 full; front wheel of one trolley stuck in soft ground, 85 s. to manoeuvre; 227 s. to load one full trolley.)	19
		8.39'40"	**Dep**	
7		8.41'00"	**Arr** (Good site, 2 trolleys with little waste outside; 167 s. to load one trolley, 247 s. to load other; rat holes.)	2
		8.50'40"	**Dep**	
8		8.52'10"	**Arr** (One trolley approx. 2/3 full; but much on ground)..	10
		9.01'30"	**Dep**	
9	310	9.04'50"	**Arr** (Hotel. Waste in side room, waste very wet, all loaded manually, loaders walk in waste; some waste in plastic bags; loading cycle 56 s.	13
		9.20'	**Finished** (Tea break - washed well first)	
		9.33'22"	**Dep**	
		(9.35'47"	Arrive hotel; truck reverses, cleaner guides.)	
10	311	9.38'42"	**Arr** (Garbage in room; loaded in plastic bags and bowls.)	18
		9.58'	(Vehicle and area washed down; breakfast break)	
		10.15'	**Dep**	
	313	10.23'	**Arrive check point**	
		10.29'	**Depart check point**	
	318	10.43'	**Arrive weighbridge** (Water still draining from load.)	
		10.47'	**Depart weighbridge**	
		10.56'30"	(Turning off main road onto road leading to tip)	
	322	10.58'	**Arrive Malad disposal site**	
		11.01'	At tipping place	
		11.03'	Body empty; hopper to be cleaned	
		11.08'	Hopper clean	
	323	11.10'30	**Depart disposal site**	
	323	11.13'	Arrive main road	
	327	11.20'	**Arrive weighbridge**	
		11.24'26"	**Depart weighbridge**	
			(Traffic delays because of road works)	
	335	11.48'30"	**Arrive chowki** (Tools returned. Log sheet)	
		11.51'40"	**Depart chowki**	

Weights: (A second load, in the same vehicle, was weighed on 1 December)

		Both axles [kg]		Front axle [kg]		Rear axle [kg]	
		25 Nov	1 Dec	25 Nov	1 Dec	25 Nov	1 Dec
Empty	Written on cab	9,180					
	Measured	9,360	9,360				
Loaded	Written on cab	16,200		6,000		10,200	
	Measured	16,500	17,440				

CC-I.2 Contractor's truck - 'B' -, 26 November

Vehicle Type: Contractors - open truck
Truck body - Height 1.37m , Length 3.86m, Width 2.30m, Tailboard ~ 56cm high.

Refuse containers: Most refuse in steel pipe sections about 1m diameter.

Station	Distance meter (km)	Time	Notes	No of Bowls
	424	7.26'30"	**Depart motor loader chowki** (Crew have one two-prong rake. 1 spade, 1 broom, 1 bowl)	
1	424	7.30'	**Arr** (Two men in truck to receive loads, one sweeping. Dry waste - leaves, soil.)	4
		7.35'40"	**Dep**	
2	424	7.37'05"	**Arr** (Two men lift ring. Site clean.)	7½
		7.42'27"	**Dep** (Truck moves at 10 km/hr)	
3	427	7.44'	**Arr** (Much foliage - another vehicle will collect tree cuttings. Labourers pulling branches apart and away from refuse. 40L bin brought by lady. 1.2 m dia riveted ring. Two labourers without footwear. Dryish waste.)	4
		7.54'05"	**Dep** (1 loader walking to next station)	
4	427	7.58'	**Arr** (Foliage removed. Two lift ring. Branches broken. Waste fairly dry. Overseer present.)	13½
		8.05'40"	**Dep** (Truck speed up to 20 km/h.)	
5	428	8.13'	**Arr** (Waste in rectangular cage. Dry waste and foliage. Bowls carefully inverted to make pile at front of truck. Basket from lady who had made house to house collection.)	19
		8.22'50"	**Dep**	
6	428	8.25'50"	**Arr**	6
		8.29'50"	**Dep**	
7		8.33'20"	**Arr** (Pipe bin - small quantity of dry waste.)	4
		8.36'50"	**Dep**	
8		8.38'	**Arr** (Driver always stops engine for loading. Garden area - leaves and branches.)	4
		8.41'	**Dep**	
9	429	8.43'04"	**Arr** (Steel ring and rag pickers. Clearing outside ring first - 14 bowls. Wet waste, plenty of flies. Bin dimensions major axis minor axis height 1.26m 1.15m 0.6m Distorted ring was full. Rag picker watches as waste is lifted. Ring held 18 full bowls.)	29
		9.00'	**Dep** (Vehicle reverses out. Turning takes long time. Waste in truck is in vertical columns - there seems to be considerable space between each 'column').	

contractor's truck - 'B' - continued

Station	Distance meter (km)	Time	Notes	No of Bowls
10		9.10'	**Arr** (Big pipe bin (riveted) with more around. First bowl very full. One rake between the whole crew is not enough. Medium waste - plenty of old sugar cane - which is lifted out of bowl and thrown forward. When truck is nearly full, there is only enough space for one man to receive and empty the bowls in the truck. Insecticide in coconut shell spread over site.)	
		9.27'	**Dep** (Waste up to tailboard, but tailboard still open. Very busy traffic. 3 minutes to do 'U' turn.)	
11	430	9.32'10"	**Arr** (Ring 1.17m dia, 0.64 m high about 10% overloaded and extra around. About 12 bowls within ring. Waste is wet and heavy. Lady with 30L bucket. 12 yr. old girl with 30-40 L bucket - too heavy for her.)	16
		9.39'45"	**Dep** (Typical speed 14 km/h)	
12		9.46'37"	(Stop for one basket - then reversing alongside hotel in shopping area. Loaders had to move car sideways to allow truck's approach. Another car moved by its driver.)	1
13		9.54'50"	**Arr** (Hotel - food waste. Extra bin with broken glass and wet waste. Tailboard closed for last few loads. Insecticide spread.)	9
		10.03'30"	**Dep**	
14	431	10.06'30"	**Arr** (Waste in kerosene or ghee tins ~ 10 tins. Baskets and sacks emptied and returned. Overseer checks paperwork.)	5
		10.10'30"	**Dep**	
15	432	10.13'05"	**Arr** (Compactor trolley bin tipped over to empty. [Overseer had required crew to do extra load.] Drain adjacent totally blocked but dry. Bowls passed over tailboard. Filling - full at back - about 20 cm above tailboard, but middle not full. Covering with gunny tarpaulin takes 2 - 3 min.)	13
		10.26'20"	**Dep** (Four ride on top of cab, two in cab, one in back with load. Open road speed ~ 30 km/h)	
	434	10.35'30"	**Arrive checkpoint**	
		10.39'	**Depart checkpoint** (Load has settled. Final volume - straight line from top at front to top of tailboard. But voids within load - say 20% of volume.)	
	439	10.53'40"	**Arrive weighbridge**	
		10.56'	**Depart weighbridge**	

contractor's truck - 'B' - continued

Station	Distance meter (km)	Time	Notes	No of Bowls
	444	11.06'45"	**Arrive disposal site**	
		11.08'44	Stopped on tip at unloading point. (Longer handled tines for pulling waste out - feet of labourers covered in waste. Even plastic bags separated but plastic bottles ignored. At least 15 open trucks here unloading at a particular instant. Municipal truck has many children around it. Trucks slip and dig into waste when trying to pull off upgrade after emptying. Sacks of recyclables thrown off incoming trucks. Truck floor lumpy - corrosion tears.)	
		11.42'	Truck empty	
		11.44'	Pulls away	
		11.46'	Stopped at gatehouse of disposal site, labourers wash	
		11.52'20"	**Depart disposal site**	
	448	12.02'35"	**Arrive weighbridge**	
		12.04'35"	**Depart weighbridge**	

Weights:

		Both axles [kg]
Empty	Written on cab	not shown
	Measured	4,840
Loaded	Written on cab	not shown
	Measured	7,900

Volume: 7.6 m^3 (Appendix CC-I.6)

CC-I.3 Compactor truck - 'C' -, 30 November

Vehicle Type: Airtech Schörling (older type; carrier plate rams internal [figure CC-III.1])
Total body volume approximately $15m^3$ (Appendix CC-I.6)

Station	Distance meter (km)	Time	Notes	No. of bowls
	1087	8.02'	**Depart motor loader chowki**	
1	1089	8.10'08"	**Arr** (Large amount of paper; muddy surface makes it difficult to move trolley; 212 s. to lift and empty trolley.)	6
		8.19'00"	**Dep**	
2	1089	8.21'10"	**Arr** (Large numbers of flies; trolley full but not heaped; 7 bowls fill hopper, 35 s. cycle time for packer plate; waste is loose, dry, vegetable.)	18
		8.33'10"	**Dep**	
3	1089	8.34'10"	**Arr** (Front *[jockey]* wheel damaged, at an angle, so trolley was difficult to move.)	1
		8.38'23"	**Dep**	
4	1090	8.39'20"	**Arr** (Near school, large proportion of paper; picker was collecting paper; surroundings clean)	
		8.43'28	**Dep**	
5	1090	8.45'54	**Arr** (Trolley very full, one wheel broken - trolley required 6-7 men to slide it into position; piles of refuse around trolley; loaders working fast)	12
		8.56'25	**Dep** (loaders walking to next station)	
6	1090	8.57'30"	**Arr** (Trolley light, approx. ½ full dry waste; loading would have finished at 9.00'35" but for sweeping up of powdery waste that fell from truck between hopper and body)	1
		9.01'55"	**Dep** (Busy road)	
7	1091	9.05'	**Arr** (Trolley completely broken, waste in front and on side; some loaders waiting while others loaded bowls; packing cycle 35 s., loading cycle (lifting to lowering of trolley) 54 s.; 2 bins brought by others (sweepers?); 2 cows feeding)	8
		9.14'20	**Dep**	
8		9.15'12	**Arr** (Everything OK - trolley in good condition, little waste around, trolley full - slightly heaped; 1 bowl of spillage; sweeper brought two baskets.)	4
		9.20'	**Dep**	
9	1092	9.20'57	**Arr** (Trolley not full; some paper scattered; picker present; waste has high moisture content)	4
		9.25'30"	**Dep**	
10		9.28'10"	**Arr** (Busy road; reversing to trolley; trolley 2/3 full; site left very tidy; 4 minute break for water)	1
		9.36'35"	**Dep**	

Station	Distance meter (km)	Time	Notes	No. of bowls
11	1092.9	9.41'40"	**Arr** (Rough ground; trolley about 80% full; problems manoeuvring trolley; hopper filled with 8 bowl loads; Plastic bags)	9½
		9.53	**Dep**	
12	1093	9.58'10"	**Arr** (Level ground; trolley well heaped; site clean; spillage about ½ bowl)	
		10.03'00"	**Dep** (Walking to next station)	
13	1093	10.03'30	**Arr** (Trolley amidst parked cars; good surface; trolley 80% full)	
		10.07'05	**Dep**	
14	1094	10.09'30	**Arr** (Trolley had damaged front wheel; trolley 80% full, 6 labourers needed to move it; clean site; truck blocking lane during operation)	2
		10.16'20"	**Dep**	
15		10.22'45"	**Arr** (Clean site; trolley 80% full; no problems)	
		10.28'05"	**Dep**	
16	1095	10.29'20"	**Arr** (Trolley approx. 2/3 full; ideal conditions)	
		10.31'07"	**Dep**	
17	1095	10.33'35"	**Arr** (Trolley very full; heavy waste on all sides; said to be two days' waste; front wheel of trolley broken so that front of trolley was resting on road; six could not move it so truck was manoeuvred closer; 7min 45 s. to lift and empty trolley)	12
		10.54'00"	**Dep** (Truck full; maximum speed rarely 40 km/h)	
	1098	11.03'50"	**Arrive checkpoint**	
		11.06'40"	**Depart checkpoint**	
	1100	11.11'	**Arrive weighbridge**	
		11.17'	**Depart weighbridge**	
	1105	11.26'55"	**Arrive disposal site** Approx. 4m 50s spent at tipping face	
	1105	11.36'	**Depart disposal site**	
	1110	11.45'	**Arrive weighbridge**	
		11.51'	**Depart weighbridge**	
		12.10'	**Arrive motor loader chowki** (tools deposited)	
	1115	12.13'10"	**Depart motor loader chowki** (Part of route on dual carriageway - speeds up to 50km/h)	
	1127	12.47'40"	**Arrive Bandra depot**	

Weights:

		Total [kg]	Front axle [kg]	Rear axle [kg]
Empty	Written on cab	8,990		
	Measured	8,900	2,942	6,080
Loaded	Written on cab	15,244	5,080	10,164
	Measured	16,220	3,700	12,320

CC-I.4 Contractor's truck - 'D' 2 December

Vehicle Type: Contractors - open truck
Truck body - Height 1.3m , Length 3.8m, Width 2.28m.

Station	Distance meter (km)	Time	Notes	No. of bowls
	842	7.30	**Depart motor loader chowki**	
1	842	7.45' 8.35'	**Arr** (The waste is mostly food waste and paper) **Dep**	79
2		8.42' 8.48	**Arr** (Mostly vegetable waste and coconut shells) **Dep**	6
3		8.55' 9.15'	**Arr** (Food waste, paper and leaves) **Dep**	42
4		9.20' 9.32'	**Arr** (Mostly food waste) **Dep** (The crew were planning to go to the disposal site at this stage, until the observer asked them to go via the weighbridge. When they knew that the load was to be weighed, they decided to collect more waste before going to the weighbridge.)	21
5		9.35' 10.10'	**Arr** (Food waste, old flowers, dry leaves) **Dep**	62
6		10.14 10.28	**Arr** (Food waste and paper) **Dep**	30
		11.05 11.55	**Arrive disposal site** **Depart disposal site**	
	867	12.30'	**Arrive motor loader chowki**	

Weighbridge readings [kg]:

Empty	4,890	Loaded	8,790

Volume of load: Body volume 11.3 m^3 (Appendix CC-I.6)

CC-I.5 DATA FROM MOTOR LOADER CHOWKI LOGBOOK

This appendix provides some information taken from the motor chowki log book. The main aim in collecting this information was to check the data collected by following the collection vehicles (as presented in appendices CC.I.1 to 4), to see if this data is typical of normal rounds (i.e. when the crews are not being observed).

(i) Time at disposal site - compactor trucks

Information was taken from the motor loader chowki concerning the collection round that was taken by compactor truck 'A' on 25 November. The start time of the morning shift, the time of arrival at the disposal site, and the length of time spent at the disposal site for a number of days in November 1992 are shown in the table below

Table CC-I.1 Arrival times at disposal site

Day in November	6	7	8	9	10	11	12	13	14	15	16	17	18
Day of week	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
Start time	7	7	7	7	7	7	7	7	7	7	7	7	7
Arrival time at tip	11.50	11.40	11.45	11.40	11.20	10.50	11.15	12.30	11.00	(1)	11.25	11.30	11.55
Time spent on tip (min.)	10	15	10	10	10	10	10	10	10	(1)	15	10	10
Arrival times at tip of vehicles from other rounds						11.05 10.20	10.50 11.00 10.45 10.55	10.35 10.50		10.00 10.10 11.10 10.45 10.25			10.50 10.58 12.10 10.45 10.15

Notes

(1) Vehicle breakdown during previous collection round

Comments: There is some indication that the rounds may not be of equal size, that is, that some rounds take more time to complete. This difference may be due to the number of stops that must be made, the condition of the trolleys, the distances that must be covered, or the traffic conditions. This difference is suggested in the data for 18th November, when one truck arrived at the disposal site almost two hours after one of the others.
It appears from these records that the collection rounds on Sundays take less time. This may be because the traffic is lighter, or because fewer mukadams are available and so there is less supervision, resulting in lighter loads.

(An anecdote related by the Junior Overseer at the motor loader chowki gives an indication of the attitude of one of the compactor truck drivers to his work. It was told that one driver always drives the same truck, and that when this particular truck is off the road for repairs or maintenance, he prefers to take leave rather than to drive another truck. With an attitude like that, one may be sure that the driver will take care of his vehicle to the best of his knowledge and ability.)

(ii) Contractor's open trucks

The records showed that there were usually twelve contractor's trucks working in the mornings and ten during the afternoon. Thirteen were engaged one morning when there were too few municipal vehicles.
According to the records, all the contractor's trucks start the morning shift at 7.00 am and the afternoon shift at 2.00 pm.
Some brief extracts from the records are shown below

Table CC-I.2 Timings of open trucks on disposal site

Day in November	11 Wed	12 Thu	13 Fri	14 Sat	23 Mon	24 Tue
Time of arrival at disposal site (morning shift)	11.20 12.45	10.05 11.10	10.20 11.10	10.15 12.10	10.40, 10.40, 10.45, 10.50 11.05, 11.10, 12.55	10.15, 10.30, 10.50, 10.50, 11.20
Time spent unloading at disposal site (min)	10 (1) 30	30 30	30 30	35 43	35, 35, 30, 35, 35, 30, 35	30, 25, 35, 35, 35
Time of arrival at disposal site (afternoon shift)					5.05, 5.40, 5.40, 6.20	
Time spent unloading at disposal site (min)					25, 25, 25, 25	

Notes

(1) This time seems very small, and so may have been recorded incorrectly

It is mentioned in Part D that the times at which trucks leave the main disposal site are not recorded. It appears that the times of departure are sometimes recorded at the Malad site.

(iii) Tractors and trailers

The records show that two tractors with trailers are employed in the ward each day, starting the morning shift at 7.30 am. The number of trips for each tractor and the times of arrival at the disposal site are shown in the table below. The records show that the tractors are on the disposal site for 10 minutes.

Table CC-I.3 Operational data for tractors and trailers

Vehicle	Date	11 Nov	12 Nov	15 Nov	17 Nov
Tractor 1	**Number of trips**	4	2	5	4
	Arrival time at tip			8.30, 9.55, 10.20, 11.25, 12.15	8.35, 9.40, 10.45, 11.50
Tractor 2	**Number of trips**	4	4		4
	Arrival time at tip				8.35, 9.40, 10.45, 11.50

CC-I.6 VEHICLE VOLUMES

(i) Compactor trucks

There were two types of compactor truck operating in K-West Ward:

- The older type has all the hydraulic cylinders that operate the carrier and packer plate (figure CC-III.1) inside the hopper side walls, and has a single three stage telescopic ram operating the ejector plate. The compactor truck labelled 'C' (Appendix CC-I.3) is of this type. Since the rams are all inside the side walls, they are more exposed to dust, and so the seals are likely to have a shorter life. The catches that hold the hopper onto the body when the hopper is lowered appeared to be inadequate.
- The newer type has a very similar external appearance, except that the two carrier plate rams are outside the side walls of the body. The ejector plate arrangement is very different - there are two separate rams: one pushes a sliding frame and the other pushes the ejector plate relative to the sliding frame. Truck 'A' of Appendix CC-I.1 is of this type. There is some uncertainty about the internal dimensions that are presented below, because the ejector plate of the vehicle that was measured was not fully retracted.

Note: Both of the models mentioned above are Airtech Schörling, and should not be confused with the completely different Airtech Multipack, which was not in operation in K-West Ward at the time of the study. The Multipack has two large rams above a lower body, and these two rams are used for raising the trolley containers and packing the waste, and raising the hopper during unloading. The system for operating the ejector plate was not observed.

Figure CC-I.1 Definition of dimensions for Table CC-I.1

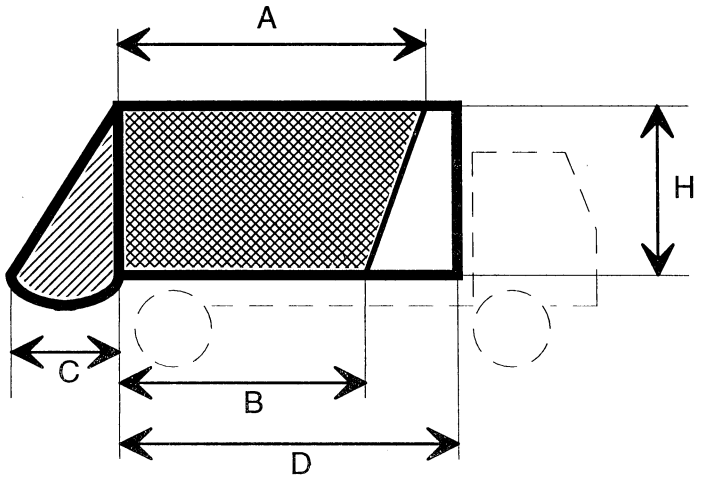


Table CC-I.1 Dimensions and volumes of compactor truck bodies

Body type [Appendix No.]	A m	B m	C m	D m	H m	W [width] m	Hopper volume [m^3]	Volume of fixed body [m^3] ½[A+B].H.W
'C' [CC-I.3]	3.35	2.65	0.6	3.57	2.00	2.30	1.4	**13.8**
'A' [CC-I.1]	3.25	2.55	0.6	3.75	1.80	2.23	1.2	**11.6**

(ii) Contractors' open trucks

The volume of refuse in an open truck is difficult to determine because there is no clearly defined top surface to the load - it can be piled up above the top of the body, or it may be above the body in some parts and below the top of the body in other parts. It is difficult to assess how high the load is in the middle of the body when looking from ground level. It also appeared during observations that refuse was piled up in columns as one bowl's contents are placed exactly above the contents of the preceding load. This technique may lead to gaps in the waste. It was observed that the waste settled in transit, probably as a result of vibration.

Figure CC-I.2 Dimensions for calculating the capacity of open trucks

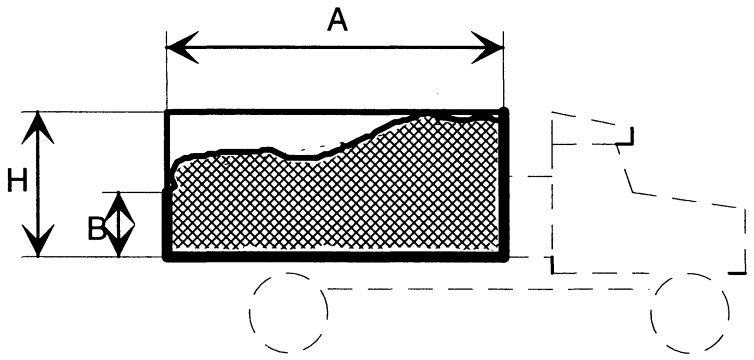


Table CC-I.2 Estimates of refuse volumes in open trucks

Vehicle identification [Appendix]	A [m]	B [m]	H * [m]	W [width] [m]	Estimate of percentage of voids	Estimate of volume of refuse [m^3]
B [CC-I.2]	3.86	0.56	1.37	2.30	20	**7.6**
D [CC-I.4]	3.80	-	1.30	2.28	-	**11.3**

Notes:

B It was estimated that the waste was piled about 20cm higher than the top of the tailboard; the top of the load was assumed to follow a straight line to the top of the front of the body.
The refuse seemed to settle to the top of the tailboard before arrival at the disposal site - if the overall settlement was 30 cm (the deeper parts settling more), and the percentage of voids is ignored, the volume of refuse is 6.8 m^3.

D No further information is available

APPENDIX CC-II.1 MCGB ESTIMATES OF VEHICLE COSTS

Cost comparison of various types of vehicles

	Types of vehicles		
	OPEN TRUCK	COMPACTOR	DUMPER PLACER
	Rs	Rs	Rs
Cost of vehicle (Approximately)	400,000	650,000	450,000
Depreciation/shift (Life = 10 years)	55	90	65
Interest on capital/shift (@ 12% per year)	65	110	75
Wages of Driver and Cleaner per shift	100	100	100
Fuel and Lubricating oil charges (for 50 Km/shift)	50	50	50
Maintenance & repair charges per shift	75	75	75
Other miscellaneous charges (like taxes per shift)	15	15	15
Cost of vehicle per shift	360	440	380
Cost of labourers per shift	350	350	300
	(6 lab + 1 Muk)	(6 Lab + 1 Muk)	(6 Attendants only)
	710	790	680
Supervision charges	105	110	100
Total cost of transportation of refuse/shift	815	900	780
Average weight removed by vehicles in a shift [tonnes]	3.5	7.0	12.0
Transport cost/tonne	235	130	65
Average volume removed [m^3]	6	22	30
Cost per m^3.	135	40	26

APPENDIX CC-II.2 CALCULATION OF UNIT COSTS FOR COMPACTOR TRUCKS USING *SENS* PROGRAM

This appendix first considers how to convert the data from earlier appendices to suit the requirements of the program, and then presents the unit costs. A manual for the program is available at WEDC; some familiarity with this manual will assist the reader to follow this appendix. The *SENS* program is a tool to allow the estimation of unit costs and can be extended to systems that are not in current use. It breaks the collection operation into a number of different steps, using data for each individual step to synthesise times and costs for new operations. The program considers up to five alternatives simultaneously. In the first section, four sets of data will be considered:

A This refers to data collected for compactor truck A on 25 November, as presented earlier in Appendix CC-I.1 .

C This column is based on data for compactor truck C on 30 November (Appendix CC-I.3).

MCGB This column uses data presented in a report by MCGB, as presented in Appendix (CC-II.1), together with data drawn from A and C, which are shown in brackets.

New This column is a proposed alternative to the existing system. Since wage costs are a major part of current costs, this proposal aims to improve manpower productivity by providing more trolley containers, and spending more on maintaining them. If all of the waste is in the trolleys, and if the trolleys are kept in good condition so that a smaller crew can manoeuvre them into position, it should be possible to operate the system with a smaller team (vehicle cleaner plus two labourers). On occasions the help of the mukadam would be needed. Times for loading are taken from times observed for compactor trucks A and C when the storage areas were in a clean condition.

Explanatory notes	A	C	MCGB	New
Design capacity (volumes from CC-I.6) [m^3]	12	15	15	12
Vehicle actual capacity ratio (If body is full = 1.0)	1	1	1	1
Compaction ratio (Density of waste estimated by estimating volumes of waste in each weighed load, by counting trolleys and/or bowls; volume of waste before compaction compared with truck body volumes. For MCGB 22/15. For *New* 1.2:1 gives a payload of 6480 kg	1:1	1.2:1	1.47:1	1.2:1
Refuse density (From weighbridge results and estimated volumes For MCGB 7000/22) [kg/m^3]	595	425	318	450
Container capacity [m^3]	1.0	1.0	1.0	1.0
Actual capacity ratio (i.e. fraction occupied. This value may need adjustment to give the actual number of collection points visited. For *New* a lower value is used since it is essential that waste does not overflow, so extra spare capacity is needed)	1.2	1.05	1	0.75
Container capital cost [Rs]	6500	6500	(6500)	6500
Interest rate (12% p.a. MCGB)	12	12	12	12
Container life span (A guess, data not available. Life likely to be longer for new system since more maintenance)	5	5	(5)	5
Days between collection (1 day assumes trolleys emptied once per day.)	1	1	1	1
Vehicle capital cost [lakh Rupees]	7.85	7.85	6.50	7.85
Vehicle interest rate	12	12	12	12
Vehicle life span [years]	10	10	10	10
Vehicle availability factor (This indicates how many standby vehicles are needed. Calculated from data in Appendix CC-III October 1972 67.9%, November 66.9%) [%]	67.4	67.4	100	67.4
Container loading time (Total time vehicle stationary at loading stations divided by number of stations. For MCGB system timing should give one trip per shift; for *New* system average of stations A.2, C.8, 12, 15, 16) [seconds]	712	439	(400)	237

Explanatory notes (continued)	A	C	MCGB	New
Team loading one container (cleaner included)	7	7	7	3
Number of loaders with one truck (as above)	7	7	7	3
Number of containers per station	1	1	1	1
Vehicle unloading time (i.e. time spent on disposal site) [min]	12.5	9.1	(10)	10
Report time, Delay allowance (Time when vehicle not moving, loading or unloading can be included as report time or as delay allowance) [min]	47.9	18	(30)	30
Time between stations (For *New* the time has been reduced because less waste would be stored on each site, so the sites would be closer together.) [s]	169	155	(150)	125
Distance between two stations (Total distance between first and last storage points divided by number of intermediate stages. For *New* it is less since more stops are made) [m]	667	375	(350)	350
Distance from collection area to boundary (Taken as half the sum of the distances from last collection point to weighbridge and from the weighbridge to the motor loader chowki) [km]	7.5	5	(5)	7.5
Distance to disposal site from weighbridge. [km]	4	5	(5)	5
Urban speed (Average speed between collection area weighbridge and chowki, and to/from depot.) [km/h]	20.1	20.9	(20)	20
Country speed (Average speed between weighbridge and disposal site.) [km/h]	23.4	31.7	(27)	27
Extra distance to the depot (both directions) [km]	24	24	(24)	24
Two shifts per day, changeover time between shifts irrelevant				
Working hours per day (In this case the time must be chosen to allow enough time for one trip per shift, but not enough for two.) [h]	12	12	(12)	12
Container maintenance cost per year (as a fraction of its annual cost...values are guesses. For *New* system more must be spent on trolleys to ensure that the wheels are always in good condition)	0.02	0.02	0	0.1
Vehicle maintenance cost per km (Based on MCGB figure with other miscellaneous charges added, and inflated by 35% for A, C and *New*) [Rs/km]	2.35	2.35	1.73	2.35
Working days per year	365	365	365	365
Fuel consumption (The vehicle is operating under different conditions- running reasonably fast, moving slowly, and stationary, operating the compaction mechanism. Estimates are very approximate. For MCGB to give a cost of Rs 50 per shift) [litres/km]	0.5	0.5	0.136	0.5
Cost of fuel per litre [Rs/litre]	6.81	6.81	6.81	6.81
Number of drivers (Two; one per shift)	2	2	2	2
Drivers wages per month [Rs]	2700	2700	1500	2700
Loader's wages per month (See Appendix AA-IV.1) [Rs]	2446	2446	1500	2446
Supervision; This is mainly to cover the salaries of the mukadams who supervise the collection crews, but can also include more senior supervisors. It is expressed as a percentage of the wages bill. For A and C one mukadam is required for a team of 8 (i.e. 12.5%), and 7.5% is added for JO's etc. For MCGB it is Rs 110 plus one mukadam (Rs 50) on a wage bill of Rs 450 per shift. For *New* it is taken as twice the value for A and C, since the wages bill is halved but the supervision costs remain the same. [%]	20	20	35.5	40
Insurance, taxes and import duties are all set at zero.	0	0	0	0
Wage overheads are assumed to cover wages of relief workers to cover one day off per week, so one days wages for six days' work gives a percentage of 16.7 [%]	16.7	16.7	0	16.7
Estimated collection cost per tonne [Rs/tonne]	**218**	**206**	**138**	**191**

APPENDIX CC-II.3 CALCULATION OF UNIT COSTS FOR OPEN TRUCKS USING *SENS* PROGRAM.

The same approach is used for the open trucks as for the compactors, except that, in the case of contractors, the vehicles and driver are paid for by means of a set hire charge, so that the calculations are considerably simpler. The following notes apply to the table below.

B This refers to data collected for contractor's truck B on 26 November, as presented earlier in Appendix CC-I.2 .

D1 This column is based on data for contractor's truck D on 2 December (Appendix CC-I.4), but considering the situation where loading stopped when it would normally be judged to be complete.

D2 As for D1, but considering also the extra refuse that was loaded onto the truck when the crew became aware that the load was to be weighed.

MCGB This column uses data presented in a report by MCGB, as presented in Appendix CC-II.1, for a vehicle owned and operated by MCGB, together with data drawn from B and D, which are shown in brackets.

Explanatory notes	B	D1	D2	MCGB
Design capacity (volumes from CC-I.6) [m^3]	12.2	11.3	11.3	12
Vehicle actual capacity ratio (For B 7.6/12.2; for D1 the number of bowl loads was counted: 148 for D1 and 240 for D2; so value for D1 is 148/240	0.62	0.62	1.0	0.5
Compaction ratio (Likely to be less than 1:1, but 1.0:1 will be used here for simplicity)	1:1	1:1	1:1	1:1
Refuse density (from weighbridge results and volumes. For MCGB 3.5 tonnes/6m^3) [kg/m^3]	403	345	345	583
Container capacity (total volume divided by number of stops e.g. for B 7.6/15, for D1 (11.3x0.62)/4) [m^3]	0.507	1.74	1.88	(1)
Actual capacity ratio (Container design not important here)	1	1	1	1
Container capital cost (Not considered here, therefore 0)	0	0	0	0
Interest rate (MCGB 12%) [%]	12	12	12	12
Container life span (Not relevant since cost is zero)				
Days between collection	1	1	1	1
(Vehicle data not required for B and D since trucks are rented; suggested 0 for capital cost and 10 years for lifetime. For MCGB see below)				
Vehicle capital cost [Lakh Rs]				4.0
Vehicle interest rate [%]				12
Vehicle life span [years]				10
Vehicle availability factor [%]				100
Container loading time (average values) [s]	504	1320	1370	(900)
Team loading one container	6	6	6	7
Number of loaders (For MCGB includes vehicle cleaner)	6	6	6	7
Number of containers per station	1	1	1	1
Vehicle unloading time (i.e. time spent on disposal site) [min]	45.6	(42)	50	(45)
Report time and delay allowance [min]	7.8	(10)	(10)	(10)
Time between stations [s]	253	380	312	(300)
Distance between stations [m]	570	(1000)	(900)	(600)
Distance from collection area to boundary (Less for contractors' trucks since they may not return to the chowki between shifts. Figures for D1 and D2 come from A and C. For MCGB as for A) [km]	3.5	(6.3)	(6.3)	(7.5)
Distance to disposal site from weighbridge (Values for D taken from A and C) [km]	4.5	(4.5)	(4.5)	(4.5)
Urban speed (All based on data for B) [km/h]	17.6	[18]	[18]	[18]
Country speed (All based on data for B) [km/h]	25.7	[26]	[26]	[26]

Explanatory notes (continued)	B	D1	D2	MCGB
Extra distance to the depot (This does not apply to contractor's vehicles since it is in their own time, therefore zero. For MCGB, as for A and C) [km]	0	0	0	24
Two shifts per day, changeover time between shifts not relevant				0
Working hours per day (Values chosen to allow two full loads)				
Container maintenance per year (Not considered here)	0	0	0	0
Vehicle maintenance (For B and D, paid by contractor, therefore zero. For MCGB Rs 75 plus Rs 15 for other charges, for approx. 50 km shift, so 90/50) [Rs/km]	0	0	0	1.8
Working days per year	365	365	365	365
Fuel consumption (Zero for B and D because contractor's responsibility. For MCGB Rs 1 per km)	0	0	0	0.147
Cost of fuel (Not relevant to B and D)				6.81
Number of drivers (It appears that one contractor's driver works for two shifts each day, but no data need be entered here since the driver is paid for as part of the hire charge. For MCGB 2, as for A and C)	0	0	0	2
Drivers wages per month (For B and D not relevant since none paid for)				1500
Loaders' wages per month (As for compactor trucks)	2446	2446	2446	1500
Supervision (One mukadam for each team of six - 16.7% plus 7.5% for JO's etc as before. For MCGB one mukadam for a team of eight - 12.5% and 105/(350+100)) [%]	24.2	24.2	24.2	35.8
Insurance, taxes and import duties (Zero as before)	0	0	0	0
Wage overheads (For loaders with B and D as for A & C) [%]	16.7	16.7	16.7	0
Rental per shift for contractors' vehicles [Rs]	230.4	230.4	230.4	-
Estimated collection cost per tonne [Rs/tonne]	**381**	**480**	**298**	**222**

APPENDIX CC-III DATA FROM VEHICLE WORKSHOPS RECORDS

APPENDIX CC-III.1 WORKSHOP RECORDS FOR 13 COMPACTOR TRUCKS AT BANDRA DEPOT, OCTOBER 1992

This table shows the numbers of compactor trucks that were available during most of the days in October 1992, and reasons why the other vehicles were not available.
The word *repairs* should be taken to include routine servicing, and *test preparation* refers to the annual roadworthiness test and includes the time taken by the test itself.

Day in October	Available	Chassis repairs	Body repairs	Test preparation	Spare
1st	9	1	2	1	
3rd	9		3	1	
6th	8	2	2	1	
7th	9		3	1	
8th	8	1	2	2	
9th	9	1	1	2	
10th	9	1		1	2
12th	9	1	1	1	1
13th	9	3		1	
14th	9	2		1	1
15th	7	3	2	1	
16th	8	3	1	1	
17th	8	3	1	1	
19th	8	3	1	1	
20th	9	2	1	1	
21st	9	2	1	1	
22nd	9	2	1	1	
23rd	9	2	1	1	
24th	8	3	1	1	
27th	8	4		1	
28th	9	2	1	1	
29th	9	2	1	1	
30th	9		1	2	1
31st	9	1	1	2	
TOTALS	207	44	28	28	5

APPENDIX CC-III.2 WORKSHOP RECORDS FOR 13 COMPACTOR TRUCKS AT BANDRA DEPOT, NOVEMBER 1992

Notes A blank indicates that the vehicle was available
M indicates mechanical repairs, relating to chassis, motor, transmission etc
A Airtech - repairs associated with the body and compaction mechanism (made by Airtech)
P "Passing" - preparation for annual test, and taking the test.
Ser means the vehicle is in the workshop for routine servicing.
Sp means the vehicle was operational but not used; it was being kept as a spare.

Date in	Compactor trucks, identified by numbers on registration plates												
Nov.'92	413	444	455	486	528	550	572	592	7632	7634	7636	7721	7738
1st			M	M				M	P				A
2nd			M	M				M	P				A
3rd			M			P		M	P				
4th	Ser		M			P	A	M	P				
5th			M			P	A		P				
6th						P	A		P	Sp			
7th						P			P				M
8th		A				P			P				M
9th		A				P			P				M
10th		A				P			P				M
11th		A				P			P				M
12th		A		M		P			P		Ser		M
13th			M			P	M		P		M		
14th						P	M		A		M	A	
15th			M			P	M		A		M	A	
16th			M			P	M		A		M	A	
17th						P	M		Sp		M	M	
18th							M				M	M	
19th			P				M				M	M	
20th		M	P				M				M		
21st		M	P				M				M		M
22nd			P				M			M	M		M
23rd			P				M			M	M		M
24th			P				M			M	M		
25th			P				A		Sp		M		
26th			P				A		Sp		M		
27th		Ser	P				A				M		
28th			P				Sp		Sp		M	M	
29th			A					M			M	M	
30th			A					M			M	M	

APPENDIX CC-III.3 EXTRACTS FROM VEHICLE RECORDS

The following extracts give some appreciation of the types of records that are kept, and how the data are presented.

(i) Status of vehicles

There are 76 vehicles at this Depot. Of these there are two types associated with solid waste collection: *Refuse* trucks which are open, high-sided vehicles which tip to unload, and *Refuse compactors*, of the type described in Appendix CC-I.6. For the four wards served from this depot, three refuse trucks are required for the first shift, and three for the second. Nine compactors are required for the first shift, and eight for the second.

Category	PS Proposed to scrap	PP Police passing (i.e. preparation for annual test)	LL Long lay up (i.e. laid up for over a month)	RR Running repairs	AV Available
Refuse Trucks (total 12)	4	5		1	2
Refuse compactors (total 13)				5	8

(ii) Repairs to compactor trucks

The following problems were abstracted from the depot records to illustrate the types of work carried out by the maintenance crew. This table adds more details to the information presented in Appendix CC-I.2.

Day in November 1992	Vehicle identification	Description of defect
6	572	Lifting arm jack pin
9	7738	Right side pulling, no pickup
11	444	Airtech (body repairs)
12	486	Gear lever broken, labourers' seat needs welding
13	455	Radiator hose leak, silencer
	572	Front left handle damaged
14	7636	Chassis cracked
	7632	Packer jack leaking
	7721	Body mounting angle cracked
16	455	Rear leaf spring broken
19	572	Bosch pump
20	444	Differential oil leak, radiator choked, manifold, spring assembly
23	7634	Alternator failed, ram oil leak
24	572	Fan belt
25	572	Ram oil leak
28	7721	Clutch bolt
30	7721	Front joint broken, gear box
	592	Steering clutch

(iii) Repairs to compactor bodies

The bodies of compactor trucks are subject to high stresses in a corrosive and dusty environment, so it is inevitable that problems develop and repairs are required. A quick

perusal of the repair records indicated that the following repairs had been undertaken for the fleet of compactor trucks at Bandra: (The vehicle components are shown in figure CC-III.1)

Figure CC-III.1 Definition of compaction mechanism components

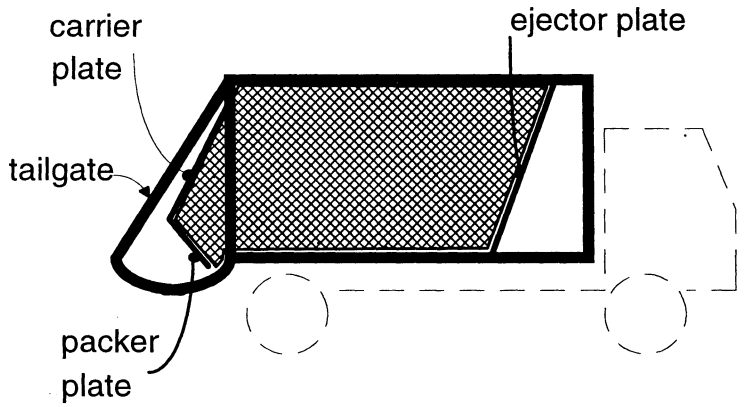


Plate base of hopper corroded; replaced
Tailgate jack mounting
Welding packer plate
Hydraulic pipe broken
Packer plate slow (two trucks)
Lifting arm pin broken
Carrier plate checked
Packer plate came out
Container lifting bracket
Packer plate jack leaking
Oil pipe broken
Ram oil leak
Oil leak on power takeoff
Tailgate jack broken
Packer plate bracket
Tailgate jack came out

This list only gives an indication of the type of problem that is experienced. A more detailed scrutiny of the records might lead to useful information which would assist in the prevention or early diagnosis of failures.

(iv) Clutch repairs

In refuse collection vehicles, clutches are often the most commonly replaced components. It takes about 6 hours to replace a clutch. The following extract from the servicing records indicates the frequency at which clutches have been replaced for some of the compactor trucks.

The clutches of refuse trucks (simpler vehicles that are less heavily loaded than compactor trucks) are quicker to replace, and last longer (often more than one year).

Vehicle registration number	Months when clutch replaced	Average clutch life (months)
7632	9/91, 12/91, 4/92	3.5
7634	8/91, 1/92, 2/92	3
7636	7/91, 11/91, 1/92	3
413	8/91, 11/91, 11/91, 2/92	2
444	5/91, 10/91, 4/92	5.5

(v) Other data and information from informal discussions

- Compactors are given priority with respect to servicing and repairs.
- Fuel consumption estimates: compactor trucks - about 20 litres per shift
  refuse trucks - about 4 km/l.
- A history document is kept for each vehicle at Santa Cruz, but maintenance costs are not recorded.
- Diesel fuel supplied from the pump at Bandra costs Rs 6.81 per litre.
- Airtech, the manufacturers of the compactor bodies and trolley bins, give a guarantee of 2 years on the compactor bodies, and provide their own mechanics to service the bodies. Airtech have trained the municipal staff to carry out repairs and have helped with repairs of vehicles even after the warranty period on those particular vehicles has expired.
- No tax or insurance charges are payable for the refuse collection vehicles.
- Cleaners always accompany drivers of heavy vehicles. The cleaner's job includes checking the oil, water and diesel fuel levels of the vehicles. They are paid Rs 2250 per month, plus an extra monthly *waste allowance* for working with refuse trucks.
- A mechanical road sweeper is owned by MCGB; spares for it are not readily available so it is used only occasionally - for one shift each week on Sundays.

APPENDIX CC-III.4 STAFFING AT BANDRA DEPOT

The following is a list of the establishment at Bandra Depot, according to the shifts on which they are employed. The 'General' shift is a normal daytime shift not related to any of the three shifts.

Job description	Shift			
	General	First	Second	Third
Sub Engineer	1			
Junior Engineer	1			
TTK		1	1	
SR	1	2		
SA	1			
Foreman	1			
Assistant foreman	1			
Mechanic	3			
Fitter I	7			
Fitter II	5	1	1	
Welder II	2			
Carpenter II	2			
Tyre man	1			
Tyre pressure man	1			
Auto Electrician	1	1		
Helper	1			
Cleaner	3	15	14	
Labourer	19	3	1	
Oil/greaser	1			
Washerman	1		1	
Sweeper	1	1	1	
Driver	8	35	25	4
Ambulanceman cum driver	2	1	1	1
JCB operator		1		
TOTALS (ALL SHIFTS 176)	**65**	**61**	**45**	**5**

PART D

RESOURCE RECOVERY AND DISPOSAL IN BOMBAY

LIST OF CONTENTS

D-1 INTRODUCTION

This part of the report is concerned with what should be done with the solid waste - its final destination. There is a growing concern around the world that solid waste should not simply be disposed of, but that, as much as possible, materials in the waste should be reused, to reduce the requirement of land for disposal - and the environmental pollution associated with such disposal - , and so that the economic value of the waste, in terms of natural resources, foreign exchange and employment creation, can be fully exploited.

The first section is concerned with present landfill disposal operations; suggestions are made as to how these operations could be improved. Then the informal resource recovery practices are discussed. The final section deals with ways of processing the waste to make useful products.

D-2 LANDFILL

D-2.1 THE CURRENT SITUATION

(i) Basic information

The Municipal Corporation of Greater Bombay operates the following four disposal sites:

- Deonar and Shiwajinagar
- Mulund
- Chincholi at Malad
- Gorai at Borivali

The site at **Deonar and Shiwajinagar** (two adjoining areas which are effectively one site) is used to dispose of more than 80% of the solid waste of the city of Bombay. Important facts about this site are:

- This landfill site has been in operation for more than 20 years;
- The land is low-lying, being adjacent to a tidal creek, and it is being reclaimed for future use;
- The total area of the disposal site is 500 acres;
- Solid wastes from wards A,B,C,D,E,F,G,H (E), L, M & N are disposed of here;
- Refuse is brought between seven and forty kilometres to this site;
- There are 82 Municipal employees working here;
- Slaughter house waste is also disposed of at this site;
- There is no weigh bridge;
- At the time of the study (1992) there were all-weather roads to the dumping sites, and a road to connect Deonar and Shiwajinagar sites was under construction;

(ii) Operational information

- Vehicles arriving at the site are recorded at the gate. The gatehouse is elevated so that the Junior Overseer can check the loads in the vehicles to see whether the open trucks are fully loaded. The vehicles then proceed to the site for unloading. The time of arrival of each vehicle is noted, but not the time of departure.
- Six hundred to seven hundred truckloads of solid waste are received at the site each day;
- 400 to 450 truckloads of debris are received at the site each day;
- 45 to 50 truck loads of industrial waste are received at this site each month;
- Generally the contractors' vehicles operate during the day time and they unload the refuse at the Deonar site.
- Municipal vehicles usually unload at the Shiwajinagar site;

- Private vehicles are unloaded at site manually; it takes 20 to 30 minutes for unloading. The place of unloading of the private vehicles is decided by the Municipal staff. At the peak hours (i.e. between 1100 hrs to 1300 hrs) there are about 80 vehicles standing at a time on the landfill site, occupying a strip of land at least 300 metres long. This makes it very difficult to confine the active part of the site to a small area, which is one of the objectives in sanitary landfill operation.
- Municipal vehicles are mechanically unloaded; much less time is needed for this operation so there are never many municipal vehicles on the site at any one time.
- During the monsoon the refuse is unloaded along the road side in a specially designated dumping ground because the trucks would get bogged down if they tried to drive over the waste to the usual area.
- The unloaded refuse is levelled by bulldozers. There are four bulldozers attached to the Deonar site and one attached to the Shiwajinagar site. One operator and one cleaner are allocated to each bulldozer.
- Two Poclain crawler mounted excavators are working on the site. They are used for excavating refuse - waste that was dumped by the road during the monsoon, and decomposed waste that is to be taken off site. Also they help extinguishing fires by digging out burning material.
- There were fires at various places on the landfill site. It was learnt that the rag pickers set fire to the refuse to enable them to separate tin cans from the other material. They pick up steel items with powerful magnets attached to a wooden handle. These fires cause considerable air pollution which can be seen from some distance (including the flight path of the International Airport) and which has been the subject of letters of complaint from the Environmental Protection Agency.
- For extinguishing the fires, a water tanker of 8000 litres capacity has been provided at the site.
- A break-down truck (fitted with a crane that can lift vehicles) has been provided at the landfill site for attending to breakdowns and for pulling vehicles that are unable to move themselves because their wheels are slipping on the waste.
- There is a workshop near the landfill site for the maintenance of the earth moving machinery.
- A fine of Rs 100 is charged for dumping the refuse at an unspecified place.
- Decomposed solid waste is sold to private parties at a cost of Rs 100/ per truck load. The work of excavation of the digested material is done by the Corporation.
- The slaughterhouse waste and the offal are unloaded at a separate designated location within the site. There was no evidence that this material was covered. Some dogs and birds were scavenging in this area. The paunch manure was taken away for use as soil conditioner after it had decomposed and dried for some time. It was sold for Rs 250 per truck load.
- Part of the landfill site can be illuminated, but there are no lighting arrangements at the site of actual dumping. It is learnt that during the hours of darkness about 100 vehicles are received at the landfill site. It is quite troublesome to operate at and supervise the landfill site at night without proper lighting arrangements.

(iii) Further information and observations

- The official in charge of the operation of the landfill site is an Assistant Head Supervisor. He has not been trained in the operations of a sanitary landfill site and is mainly concerned with record-keeping. As a result, avoidable technical problems cannot be tackled properly.
- It was learned that no studies regarding the leachate had been carried out, nor had any analyses of the decomposed waste been performed. Leachate was observed at the landfill site. It may pose a threat to water resources and fisheries.
- As the refuse vehicles unload, rag pickers search through the piles of freshly dumped waste. There are 200 to 300 rag pickers operating at a time at the landfill site. They are mainly women, and children in the age group of 8 to 15. When the refuse is being

unloaded or levelled, the rag pickers rush towards the vehicles without seeming to pay any attention to the moving machines. This could result in a fatal accident, and the bulldozer drivers may operate their machines more cautiously and slowly as a result of this risk.

- The rag pickers set fire to the refuse with the aim of collecting tin cans and scrap more easily. This is quite hazardous from the point of view of the environment at the site. Also there is the possibility of an accident. Landfill fires sometimes continue for weeks or months on account of the presence of methane in the wastes underneath. Magnets have been confiscated from the rag pickers in an attempt to stop them from setting fire to the waste, but this has not been successful.
- All the rag pickers operate at the site without gloves or protective clothing. This represents a serious health hazard.
- No cover was being laid over the refuse after it had been levelled. It has been observed that there are soft patches and depressions on the landfill site which cause difficulties for the movement of vehicles.
- At the dumping ground about 50 truck loads of industrial wastes are received monthly. However, there is no specified secured site for taking care of these wastes. Such wastes may pose risks to personnel and scavengers on the site, and be a source of water pollution.
- There were large numbers of flies at the site, especially near freshly-dumped refuse. If flies are successfully breeding at the site, then they obviously pose a serious health hazard.
- There is a lot of airborne dust at the site especially where the vehicles unload. When the vehicles move the intensity of dust increases. This is a pollution problem and also a direct health hazard for the persons working on the landfill site.
- There are foul smells at the landfill site, especially where the slaughter house waste and offal are unloaded. This is a form of environmental pollution.
- The sanitary blocks provided at the entrance of the landfill site are not properly maintained. Also there is not a sufficient provision of water for the workers working in the landfill site.

D-2.2 COMMENT AND SUGGESTIONS

COMMENT: From the size of the site, and the number of vehicles unloading there each day, it is clear that the Deonar/Shiwajinagar site is very important. It receives almost all types of solid waste. The landfill site staff maintain quite good records regarding the registration of incoming vehicles, their loads, time of entry etc. However, with slight modifications to the present use of manpower and machinery on the site there is considerable scope for improving the site conditions and the landfill itself.

SUGGESTIONS: Human resources The success or failure of a sanitary landfill operation depends more on the people involved than on any other single factor. The subjects of training, motivation and authority need to be carefully considered.

- In Part A it was suggested that engineers involved in solid waste management should be specialists in the subject, not those transferred from other municipal duties for a short time. It is consistent with this approach to propose that an engineer who has been well trained in sanitary landfill operations should be in charge of the Deonar and Shiwajinagar site, or perhaps all of the Bombay sites. Sanitary landfilling techniques that are used in USA or western Europe may need modification before they are fully appropriate to denser waste, such as that found in Bombay. It follows that the engineer in charge of disposal must have a pioneering attitude, and be interested in undertaking field research in order to develop suitable methods of operation. An engineer with little interest or experience in the subject, and who is hoping for an early transfer away from solid waste

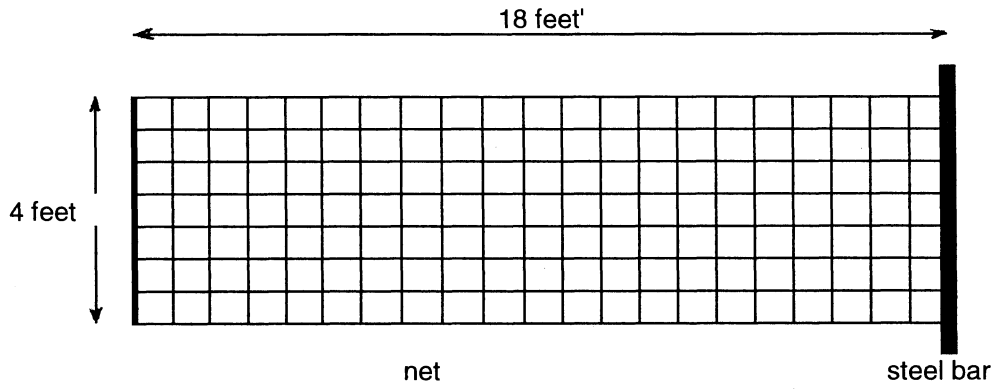
management, would not be satisfactory for this job. It may be appropriate, in the early stages, for this engineer to be assisted by a consultant when developing new methods.

- With regard to motivation of the disposal engineer, thought must be given to building up the status of the job. This might be done by choosing an acceptable title for the post, investing considerable authority in the post, providing opportunities for international travel for training purposes, and providing facilities to encourage the engineer to be closely involved with operations on site rather than staying in his office. (Such facilities might be the provision of an air-conditioned off-road vehicle. Air-conditioned vehicles are normally provided only to much more senior personnel, but are appropriate in this case because of the dusty nature of the disposal sites. Alternatively, a portable, air-conditioned office, that would enable comfortable supervision of operations, could be provided.) It would be helpful if the contract for this position included the requirement that certain goals be achieved within a specified time frame.
- In the short term, the Assistant Head Supervisor in charge of the site should be given training and support to enable him to start to make some of the improvements necessary.

SUGGESTIONS **Vehicle unloading** The long time spent unloading the open vehicles causes a number of problems: the vehicles occupy a large area and the unloading process is very unsanitary and poses health risks to the labourers The following steps could be taken to improve the situation:

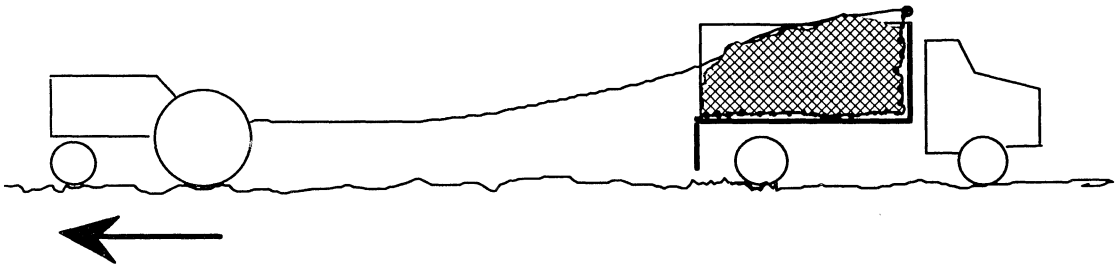
- Data should be collected on the current situation so that costs of proposed systems can be compared with any proposed variation. This will include recording the time that each truck spends on the site (i.e. recording the time of departure as well as the time of arrival).
- An obvious solution would be to use only tipping vehicles or bodies that unload hydraulically. This has been discussed in Part A, where the introduction of a longer contract period was suggested to encourage contractors to employ more suitable vehicles.
- Investigations should be carried out to find methods of unloading open trucks more quickly. Two possible methods are suggested below. The suggestions listed here are not methods that are known to have been used elsewhere, so it is necessary to undertake preliminary trials to determine whether such methods might be feasible:
  a) Before loading the vehicle a rope net such as shown in figures D-2.1 and D-2.2 is placed on the vehicle floor. To unload the vehicle, the ends of the bar could be tied to a rope so that the whole load of refuse can be pulled out of the back of the vehicle. This could be done in only a few minutes.

Figure D-2.1 Net to aid unloading open trucks



Trials would be necessary to determine whether the net should be only on the floor, or whether it should also be laid up the front of the body before the refuse is loaded, what modifications are required to the truck body (such as a taper), and how much force is needed to move the waste.

Figure D-2.2 Pulling net to unload truck



b) An excavator with a back-acting bucket might be used to empty open trucks. There would be the risk of damage to the truck bodies, so they might require strengthening. The cost of providing and running the excavators might be more than the savings accruing from faster unloading.

SUGGESTIONS Rag pickers

- Rag pickers could be given access to the waste immediately after it is unloaded. The bulldozers could come to level that waste after an agreed interval. This arrangement should avoid accidents.
- Efforts should be continued to try to prevent rag pickers from starting fires. This task calls for minimum force but strong determination. In this process, the police, as well as the leaders in the area, can play an important role.
- All plant operating on the site should be fitted with audible reversing warning signals to alert the rag pickers nearby.
- The suggestion has been made that the rag pickers should each be given a pair of hand gloves. Whilst this is necessary in terms of accident prevention it would be difficult for the MCGB to approve such an expenditure for people who are trespassers rather than employees, and it is likely that the scavengers would sell their gloves, and that the offer of free gloves would attract more people to the site. The same argument would apply to the provision of gum boots.
- The staff working at the site should take pains to educate the rag pickers with regard to fires and protecting themselves from health risks and accidents.
- An alternative approach is to formalise the rag pickers by awarding contracts for the salvage of material from the site. Such an arrangement would allow more control of the activities since the contractors themselves would take some responsibility for policing the work; only workers wearing the contractor's uniform would be allowed on the site and near the fresh waste. Offences such as starting fires would be grounds for the cancelling of the contract.

SUGGESTIONS

- It has been observed that the water table at the landfill site is quite high. It is suggested that the leachate could be utilised to control the dust. The leachate could be pumped from an excavated hole into a tanker trailer that would be pulled by the tractor (which is already available). This would also help to solve the problem of leachate to some extent. This recycled leachate could also be used for fire fighting.

- The landfill site receives about 400 to 450 truck loads of debris every day. This debris could be conveniently utilised every day for covering the levelled refuse. This would reduce the numbers of flies and minimise the smell nuisance. The slaughterhouse waste could be unloaded into ditches or pits and be covered with debris. This would keep the place more clean and acceptable. It might also be possible to use some of this debris to

improve the surface of the site, by filling in depressions and potholes and improving the traction of trucks in wet or slippery patches.

- It is suggested that a dog catcher should visit the site every day. The dogs should be caught and sent away in a dog van. This would reduce the problem of the stray dogs to some extent.

- Lighting arrangements - such as portable floodlighting sets with their own generators - should be provided at the actual unloading area. This would make the landfill site more convenient for operation during night time.

- A separate site should be specified only for dumping certain types of industrial waste. This site should be at one corner of the landfill site where the risk of pollution is least. It may be necessary to line the site with puddled clay or plastic sheet. Only some industrial wastes are hazardous and require special treatment - liaison with the industries concerned would be necessary, and the junior overseers at the gatehouse would need special training to recognise hazardous waste loads. If charges for the disposal of this waste were too high, industrial waste might be deposited illegally elsewhere.

D-3 RECYCLING

The term *recycling* is used in a number of ways; here it is used to mean the process by which waste materials are transformed into new products in such a manner that the original products lose their identities. Reuse of returnable glass bottles and retreading of tyres are not included in this definition.

This section is concerned with the recycling of materials from domestic, institutional and commercial solid waste, such as: paper, cardboard, plastics, glass (broken and whole bottles), metals. (iron, aluminium), rags, gunny bags, tyres, bones and broken asbestos shells. Section D-4 describes other resource recovery techniques - vermiculture and composting to produce soil conditioner, and pelletisation to produce fuel.

Much of the information here has been gathered by interviewing rag pickers and hawkers - women, men, boys and girls of different age groups. They were interviewed at the Deonar landfill site as well as in the city (at Dharavi, Kurla, and Sion). Appendix DD-2 shows the prices paid for various materials at different stages.

This section first discusses the ways in which recyclable materials are separated and sold through a network of dealers, and then describes how particular materials are processed.

D-3.1 METHODS OF COLLECTION OF RECYCLABLE MATERIALS

(i) From households

Recyclable items like newspaper, glass bottles, broken glass, cardboard, rags, gunny bags, etc. are segregated by the residents and sold to the hawkers, who go from door to door. The amounts paid are different for different items. The hawker sells these items on to the middleman.

(ii) From storage facilities and streets

Rag pickers pick up recyclable items from the bins, dumps and roads and sell them to middlemen. When they are looking for items from the road side, dust bins or dumping areas, the pickers spread the refuse so that they can sort through it more thoroughly. . As has been discussed in Part B, they often take the waste out of the containers and leave it on the surrounding ground. This creates a visual nuisance, may encourage fly breeding, and adds to the work that must be done by the motor loaders - the productivity of the collection vehicles is reduced because of the time they spend waiting at the collection sites while the scattered waste is being gathered up.

(iii) By municipal employees

The segregation of recyclable items by motor loaders was not observed during this study, but it has been pointed out by some sources that this practice is going on. Occasionally motor loaders in open trucks were seen to throw down some partly-filled sacks when they arrived at a disposal site, but the purpose of this action was not determined. When the loading of trucks was being observed, the rate of working was so fast that there was little opportunity for the separation of recyclable material.

(iv) From disposal sites

Rag pickers pick up recyclable items from dumping grounds where municipal solid waste is dumped by Corporation or private vehicles. The people doing this work are mostly women, but there are also girls and boys, (some of whom are as young as nine years old). Some of the pickers, especially the children, work part-time at the landfill sites.

In most cases one picker collects only one type of material. They do not wear gloves or shoes while picking at landfill sites. They bring drinking water in plastic containers.

At one landfill site it was observed that there was a rush towards each refuse truck when it arrived for unloading. The pickers were inviting injury to themselves by running in front of bulldozers.

Generally the pickers sell their materials collected by them on the same day. Sometimes they keep the items on the road-side or foot path, or near their shelter. They do not in general have any storage facilities.

(v) Direct to middleman

Good quality cardboard and items made of cardboard - i.e. packing cases of refrigerators, television sets, radios, and washing machines, and other boxes and cartons - may be sold by shops and institutions directly to the middlemen.

(v) Organisation of hawkers and pickers

There is no association, union, or organisation of hawkers or pickers; they work independently and individually. Hawkers and pickers do not appear to be interested in forming or joining any organisation because they fear the implementation of rules and regulations which they think would hamper their work.

D-3.2 PROCESSING OF RECYCLED MATERIALS

(i) Plastics

Plastics items are sold by pickers and hawkers to the middlemen, and the middlemen sell them to the owners of small-scale factories dealing with the particular material.

The different types of plastics items (sorted according to whether they are hard or soft, and according to quality and colour) are sold to the specialised small factories dealing only in plastics. These factories use machines to cut the different separated plastics into small pieces about one centimetre in size These pieces are washed in soapy water to remove

dust and dirt particles and then dried in the sun. They are then sold on to the next small industry.
The materials are converted separately into a granular form by heating and cooling. (A flow sheet showing the processes is reproduced in Appendix DD-3) These granular particles are sold to other factories for making plastic items like clothes hangers, washing brushes and soap cases. Minimum wage regulations apply to the workers in these factories.
There are some plastic items which are not suitable for recycling and therefore these are not collected by pickers. These are items like electric switches and adapters which are made from thermoset plastics.
There are some plastic items, such as pipes, which are not cut and melted down, but are kept by the middlemen and sold for reuse.
NOTE: Sufficient virgin material for the manufacture of plastics goods is not available to meet the demand and price range of the market. Therefore, there is a heavy demand for goods made from recycled plastic.

(ii) Paper and cardboard

Newsprint Newspapers and magazines are purchased by hawkers going from door to door, and sold to middlemen. Middleman sell this paper for use in packing fruit, and for making of packets of different sizes for use in small shops.
Mixed paper Paper collected by pickers from community containers and dumping grounds is sold to middlemen who, in turn, sell it to manufacturers of paper and cardboard.
Cardboard The hawkers generally purchase cardboard and items made of cardboard from households and shopkeepers directly. Cardboard is used by industries for making packing cases for consumer goods such as household appliances and shoes. People also purchase packing cases from middlemen directly for their use. Damaged cardboard is sold by the middlemen to paper mills.

(iii) Glass

Broken glass (cullet) Pickers and hawkers sell broken glass to the middlemen. The middleman sells it on to the different glass industries for making different glass items. Broken glass is also purchased directly from the middlemen for putting on the top of boundary walls for security purposes.
Bottles Glass bottles are purchased by the hawkers from households and shops. Sometimes pickers also get bottles from the road-side and refuse containers. The middlemen sell undamaged bottles to the bottling factories for their reuse.
Small bottles are also sold at the main gates of hospitals and dispensaries; patients purchase them for their medicine.
Sometimes people also purchase bottles of different sizes from middlemen for their own domestic use.

(iv) Rags and gunny bags

Rags Rags are usually sold by pickers to middlemen. Manufacturers purchase rags from middlemen for making buffing wheels. Rags are also purchased from middlemen by the paper-making industries.
Gunny bags are purchased by middlemen from the hawkers. Damaged gunny bags are sold to the paper- and cardboard-making industries. Good quality bags are reused. Partially damaged gunny bags are used by the flood control authorities for protecting embankments by putting sand into them. More seriously damaged but serviceable gunny bags are used by the pickers, hawkers and middlemen for storing material that is to be recycled.

(v) Metal

Scrap metal (galvanised iron sheets, scrap from workshops, aluminium items etc) are purchased by the middlemen from pickers and hawkers. These materials are sold directly to the factories which manufacture rods, sheets, angles etc.

D-3.3 COMMENTS AND SUGGESTIONS

COMMENTS

Thousands of people are engaged in the process of recycling (as pickers, hawkers, middlemen, and in the reprocessing factories) and so this sector of activity is an important source of livelihood. There are also less obvious benefits of recycling, such as a lower demand for natural resources and imported materials. Another advantage is the reduction in the quantity of solid waste that is to be disposed of, and the removal of troublesome materials such as plastic and paper (which are blown about by the wind).

Each recycling unit functions independently and most under very unhygienic conditions. These units are not recognised by the local competent authority, and so there is little control over working conditions and pollution. The recycling process is functioning very well from the starting point - the pickers and hawkers - to the manufacturers of the finished products without much support from the local authority. There is a sufficient market for the products made from recycled materials.

The main collection of recyclable material is done by the pickers and hawkers. The pickers create problems at the site of collection for the solid waste collection authority by spreading refuse on roadside and around storage facilities in the city and by starting fires at landfill sites.

SUGGESTIONS

- The attitude of policy makers towards informal sector recycling is important. It is suggested that a seminar on the subject would be useful, with representatives who are in contact with the rag pickers, hawkers and owners of small recycling industries, as well as from the Municipal Corporation, so that city officials can understand the perspectives of the recycling industry. A spirit of co-operation between the two groups would be greatly preferable to a spirit of confrontation and mistrust.

- Some suggestions relating to pickers at community storage sites have been mentioned in section B-3.3 (iv), and others relating to pickers on landfills have been discussed in section D-2.2. In both these situations the pickers are causing serious problems to the refuse management services, and any improvement in the activities of the pickers would be of considerable assistance to the municipal workers, and create environmental improvements.

- It is important that ways be found of preventing the pickers scattering litter around the storage facilities. The provision of extra storage capacity has already been suggested. Another possibility in some situations might be the provision of a sloping tray above the container such that waste could be dumped initially on the tray for sorting, and when the waste has been examined it could be pushed into the bin.

- Other possibilities for improving the situation around the containers include giving the sweepers a role in policing behaviour around the bins, but this could lead to more confrontation, and increase the frustration of the sweepers. Alternatively, it may be possible to enlist the help of pickers by paying them a small fee for cleaning the area around a small number of containers - though the main part of their day, and their main source of income, would still be from recycling activities. It might be possible to allocate picking rights for certain bins to certain people, but protection of these rights might be very difficult and lead to further confrontation. It has also been suggested that the middlemen might be able to control the activities of pickers and prevent littering around bins - each middleman would act as a contractor for a certain area and run the risk of a penalty if bins in his area were left in an untidy state by the pickers that he employs. The

potential success of these ideas depends in part on the working habits of the pickers - what degree of organisation exists among them, how long they continue to work as pickers, and how they divide up the city's bins among themselves.

- In many ways, the best solution is to develop the work of the hawkers, who go from house to house, buying recyclable material from residents. This approach ensures that the recyclable material is not contaminated by other waste, and it avoids the problems caused by pickers at bins and disposal sites, since, if all the recyclable materials are sold to hawkers at the door, there would be no useful material in the waste at the community bin and at the landfill site. A pilot scheme of this type has been set up in Bangalore - residents separate their waste into *wet* and *dry* streams, the *dry* containing all the recyclable material.

D-4 OTHER METHODS OF RESOURCE RECOVERY

About 99.5% of the solid waste collected from Greater Bombay is disposed of at the four landfill sites listed in section D-2 above. The remainder - about 0.5% or about 20 tonnes per day - is disposed of in ways which offer the possibility of gaining some economic benefit from the waste. These methods are:

- **vermiculture** - feeding the waste to worms in order to produce a stable soil conditioner
- **pelletisation** - drying the combustible fraction of the waste and forming it into fuel pellets
- **composting** - by the Excel process

All these methods are operating on a very small scale. It is essential to demonstrate the technical and economic feasibility of such methods on a small scale before they can be developed into large-scale operations. Some information on the vermiculture and pelletisation projects is presented below, but it was not possible to collect data on the Excel process.

For a few years a large mechanical composting plant was in operation, converting solid waste into soil conditioner. This plant is no longer in use, but it is described briefly, and reasons for its closure are discussed.

D-4.1 VERMICULTURE

Vermiculture biotechnology involves the use of earthworms as natural bioreactors for efficient bioprocessing of organic wastes into vermicastings (worm-excreta) - this material is a useful fertiliser for the soil.

Bhawalkar Earthworm Research Institute (BERI) Pune has developed a practical, cost-effective application of vermiculture biotechnology for handling (among various other wastes), the organic fraction of municipal solid waste (see reference 1).

Vermiculture products from such operations have been used by farmers successfully on diverse crops such as sugar cane, grape, guava, banana, coconut, pomegranate, chickoo, bar, vegetables. flowers, and spices in different agroclimatic conditions in India.

(i) Bio-processing under a tree

Five kilograms of vermicastings are applied as a basal dose below a tree and a 100 mm layer of household organic wastes is placed on it as a mulch. (The household wastes form a

protective layer which also serves as food for the worms hatched out.) The mulch reduces the water requirements of the tree, as evaporation from the soil is reduced. As the old layer of mulch are converted into vermicastings, new layers are added on top. Pests are significantly reduced. Trees also show healthy growth without any digging or chemical fertilisers.

(ii) Processing in a container

This process uses a wooden box of size 80 cm by 60 cm by 40 cm with the few drainage holes. Five kilograms vermicastings are applied on a layer of a used newspaper kept at the bottom of the container. Household organic waste is put into the box daily. Some water is also applied occasionally till just a few drops come out from the drain holes. A container of this size will take a year to get filled by a family of four. Lower layers can be removed and used as a rich biofertiliser for potted plants. Several families are practising such recycling in Pune, India and are spreading the news of their success.

The Indian Institute of Technology, Bombay, has been recycling the solid waste produced from ten hostels for one year using this technology.

(iii) The advantages of vermiculture technology

- Reduction of odour and fly nuisance.
- Does not consume electricity or fuel.
- Simple to operate and maintain.
- Destroys pathogens.
- Produces vermicastings which can replace costly energy-intensive, imported farming inputs such as diesel, chemical fertilisers and pesticides.
- Conversion of wastes into resources makes the operation viable and sustainable.
- Helps the economy of the country.
- Eliminates pollution totally.

(iv) Optimum requirements for the process

- Temperature to be maintained at 25-26^{o}C and always less than 30^{o}C.
- High humidity is favourable for the process.
- Neutral pH must be maintained.
- The time required for the completion of process is 8 to 10 weeks.
- Space requirement: for 1 kg. volatile solids/day an area of one square metre is required.

D-4.2 PELLETISATION

The Department of Science and Technology constructed a pilot plant with a capacity of 8O tonnes/day. The fuel pellets have a calorific value in the range of 3500 to 3700 KCal/Kg. The cost of production was estimated to be Rs.780.00/tonne and the realisation from the sale of the product is Rs 1,000/tonne. The present production of the plant is 5 to 8 tonnes per day.

(i) Problems with the final product

- It gives initial smoke.
- It burns quickly - faster than coal
- Its calorific value is less than coal.

D-4.3 COMPOSTING - EXCEL INDUSTRIES PROCESS

Excel Industries is supplied with two truck loads of market garbage for converting it into compost.

D-4.4 MECHANICAL COMPOST PLANT

(i) General information

This plant ran from December 1979 to May 1983. It was installed in Bombay jointly by the Government of Maharashtra (Municipal Corporation of Greater Bombay) and M/s Deccan Sales Corporation - a private body manufacturing granulated fertiliser. The Ministry of Agriculture gave a grant-in-aid to the extent of 33% of the capital cost of the compost plant to the Municipal Corporation. The Ministry of Works and Housing also gave grant-in-aid to the extent of 50% of cost of the various infrastructure items connected with the working of the plant. The Municipal Corporation of Greater Bombay provided 8 hectares of land for the compost plant on a lease basis for a period of 30 years from the date of possession at the rate of Rs 50/m^2. The capital cost was Rs 1.5 crores. It was supplied on a turnkey basis.

The garbage required for the compost plant was provided by the M.C.B.G. free of cost. The water required for the compost plant was provided at the concessional rate. The design capacity of the plant was 45,000 tonnes p.a..

The compost plant started operating in December 1979. In May 1981, the plant was closed because of a strike. The plant was reopened in November 1981. During the monsoons the plant did not function.

The process used was aerobic. The windrows were supposed to be 2 m high; they were covered to prevent the process of fermentation being affected by rain water. According to the design, the compost should have been ready within 7 days.

The price of the compost was as follows:

Year	1979	1981	1982
Price Rs per tonne	55	65	85

(ii) Factors which were responsible for the closure of the plant

- Some of the customers were farmers coming long distances from places such as Nasik, Pachova, Pune and Palghat. Because the farmers were unwilling to pay the high transport costs, they stopped purchasing the compost, and so not all the compost that was produced was sold. For instance, in the seven months - October 1981 to May 1982 - the production was 7699.65 tonnes but the sales were only 3533.44 tonnes (i.e. 46% of production).
- The presence of non-compostable materials like plastics, glass etc. varied in the final compost from 0.5% to 1.0%. Marketing agencies responsible for the sale of the final product indicated that the presence of such materials was hindering sales.
- The compost could not be made ready within seven days as per the design.
- The windrow height could not be maintained at 2m as per the design. It could only be maintained at 1m; this affected the biological processes and a satisfactory temperature could not be maintained and therefore the composting process was delayed.
- Auger shafts were breaking frequently due to high loads. Such disruptions affected the frequency of turning and so reduced the throughput of the plant.
- There were no spare units available to keep the plant running in case of failure of the machinery.
- The machinery, such as the grab bucket, slat conveyors, and rasping machine, could not be utilised fully to their rated capacity because of operational problems in handling the garbage. (For example the rasping machine used for shredding the waste could not shred wet garbage from the markets.)
- The formation of balls of shredded garbage slowed down the microbiological processes.
- The screening machinery allowed compost to pass with the rejects.

- Bombay garbage contained more than 50% moisture (during 1979-82) even in the dry season. The end product for sale should not have a moisture content of more than 30%. Difficulties in achieving a satisfactory moisture content reduced the quality of the end product.
- Because of these problems the full complement of staff was not appointed.

COMMENT: It appears from the history sheet of this mechanical compost plant that it was installed without consideration of the necessary factors like characteristics of refuse (moisture contents, different constituents etc), the demand for the compost, and the technical feasibility of the process (height of windrows to be maintained, the period required for preparation of compost from refuse, etc.). This experience emphasises the importance of small-scale pilot plants in demonstrating the feasibility of such an operation.

PART D

APPENDICES

APPENDIX DD-1 SOURCES OF INFORMATION

1. 'Municipal Solid Waste Management by Vermiculture Biotechnology'
Mr Udai S Bhawalkar
Director of Bhawalkar Earthworm Research Institute, Pune-37 (India)
PECR FOUNDN P-50

2. Discussion with the concerned authorities, and with rag pickers, hawkers, middlemen and small scale manufacturers

3. *Solid Waste Management in Greater Bombay,* a paper presented by Shri C. D. Kotnis
Chief Engineer, SWM, MCGB, Bombay, 1992

APPENDIX DD-2 PRICES OF RECYCLED MATERIALS

PLASTIC

Pickers' selling price to middleman		Middleman's selling price to industries for making granules for plastic products	Small scale industry selling price of granules to industry manfacturing plastic products	Remarks
Rate per Kg	Range of Rate	Rate in Rs/Kg	Rate/Kg	
Rs 0.50 Rs 3.00 Rs 6.00 Rs 10.00 Rs 12.00	Rs 0.50 to Rs 12.00	Rs 1.00 to Rs 15.00	Rs 30.00 to Rs 80.00	The prices mentioned are on the basis of interviews

PAPER AND CARDBOARD

Pickers' selling price to middleman		Hawkers' buying price from houses and shops		Middleman's buying price from hawkers		Middleman's selliing price to respective industries	
Category	Rate/Kg	Category	Rate/Kg	Category	Rate/Kg	Category	Rate/Kg
Newspaper	-	Newspaper	Rs 4.00	Newspaper	Rs 5.00	Newspaper	6.00
Other paper	Rs 0.60 to Rs 2.00	Other paper	Rs 0.60 to Rs 2.00	Other paper	Rs 0.80 to Rs 2.75	Other paper	Rs 1.00 to Rs 2.50
Cardboard	-	Cardboard	Rs 0.60 to Rs 2.75	Cardboard	Rs 80 to Rs 2.75	Cardboard	Rs 1.00 to Rs 3.50

N.B:- The selling & buying prices are based on interviews with pickers and hawkers, etc.

RAGS AND GUNNY BAGS

Pickers' selling price to middleman		Middleman's resale price		Remarks
Category	Rate/Kg	Category	Rate/Kg	
Rags	Rs 0.50 to Rs 1.00	Rags Gunny Bags	Rs 1.10 Rs 1.10	Rags are picked by pickers Gunny bags are purchased by hawkers and middlemen directly

BONES

Pickers' selling price to middle man	Remarks
Rs 0.50/Kg	Middleman sells to industry at Rs 0.80 to Rs 1.50/Kg **NB** The prices are based on the information obtained from the different persons involved.

SCRAP METALS

		Remarks
Hawkers' buying price & pickers' selling price to middleman	Middleman's selling price to industries	The prices are based on the information obtained by interviews
Rs 0.50 to 3.00/Kg	Rs 1.00 to Rs 4.00/Kg	

GLASS

		Remarks
Hawkers' buying price & pickers' selling price to middleman	Middleman's resale price to glass industries	The prices are based on the information obtained from interviews
Rs 0.70/Kg to Rs 0.80/Kg	Rs 1.40/Kg	

APPENDIX DD-3 FLOWSHEET SHOWING RECYCLING PROCESSES FOR PLASTIC